8506A

THERMAL TRUE RMS DIGITAL MULTIMETER

Instruction Manual

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Section 1
Introduction & Specifications

1-1. INTRODUCTION

1-2. This eight-section manual provides comprehensive information for installing, operating and maintaining your Fluke digital multimeter. Complete descriptions and instructions are included for the instrument mainframe, for all modules necessary in making thermal true-rms and dc volts measurements, and for any optional modules ordered with the instrument. Appropriate sectionalized information is included with any optional modules subsequently ordered and may be inserted in Section 6.

1-3. DESCRIPTION

1-4. The multimeter features 6-1/2 digit resolution, full annunciation and simplicity of operation. Modular construction, microprocessor control, and a bus structure provide excellent flexibility. Memory programming from the front panel (or through a remote interface) controls all measurement parameters, mathematical operations and special operations. The standard hardware configuration allows for measurement of thermal true-rms volts on eight ranges and dc volts in five ranges. An averaging mode is available to automatically optimize display resolution and stability for each range in dc volts, resistance, and dc current functions. Extended resolution is also available in the ac volts function. Optional modules are available for dc current (five ranges), and resistance (eight ranges) in two-wire or four-wire arrangements.

1-5. Thermal True-RMS Conversion

1-6. The thermal true-rms feature allows the operator to measure the true-rms value of an ac signal at accuracies of up to .012% with a reading rate of one every six seconds. This response time compares favorably with that of existing thermal transfer standards which can take up to five minutes to complete a measurement.

NOTE

The A3 Isolator PCB is standard in the 8506A. This assembly is documented in Section 6 of this manual as Option -08A.

1-7. Modular Construction

1-8. Considerable versatility is realized through unique modular construction. All active components are contained in modules which plug into a mainframe motherboard. This module-to-motherboard mating, combined with bus architecture and microprocessor control, yields ease of option selection.

1-9. Microprocessor Control

1-10. All modules function under direct control of a microprocessor based controller. Each module is addressed by the controller as virtual memory. Scaling factors and offset values can be applied separately, stored in memory, and automatically used as factors in all subsequent readings. Digital filtering utilizes averaged samples for each reading.

1-11. Software Calibration

1-12. The 8506A features microprocessor-controlled calibration of all ranges and functions. Any range can be calibrated using a reference input of any known value from 60% of range to full scale. Software calibration can be performed using front-panel or remote control, allowing recertification without opening the case or removing the multimeter from the system.

1-13. Recirculating Remainder A/D Conversion

1-14. The multimeter adapts Fluke's patented recirculating remainder (R^2) A/D conversion technique to microprocessor control. This combination provides fast, accurate, linear measurements and long-term stability.

1-15. Options and Accessories

1-16. Remote interfaces, a dc current converter, and an ohms converter are among the options and accessories available for use with the multimeter. Refer to Tables 1-1 and 1-2 for complete listings. Any one of the three Remote Interface modules (Option 05, 06, or 07) may be installed at one time.

1-17. SPECIFICATIONS

1-18. Mainframe specifications for ac volts, dc volts and dc ratio measurement capability are presented in Table 1-3. Optional function specifications are supplied with the respective option modules and included in Section 6.

Table 1-1. Options

OPTION NO.	NAME	NOTES
02A	Ohms Converter	1
03	Current Shunts	1
05	IEEE Standard 488-1975 Interface	2
06	Bit Serial Asynchronous Interface	2
07	Parallel Interface	2

1) Either Option 02A or Option 03 can be installed at one time.

2) Only one of Options 05, 06, and 07 can be installed at any time.

Table 1-2. Accessories

MODEL OR PART NO.	NAME
M04-205-600	5¼-inch Rack Adapter
M00-260-610	18-inch Rack Slides
M00-280-610	24-inch Rack Slides
80K-6	High Voltage Probe
80K-40	High Voltage Probe
83RF	High Frequency Probe
85RF	High Frequency Probe
Y8021	IEEE Std. Cable, 1 Meter Length
Y8022	IEEE Std. Cable, 2 Meter Length
Y8023	IEEE Std. Cable, 4 Meter Length
629170	TRMS Extender Card
MIS-7190K*	Static Controller
MIS-7013K*	Bus Interconnect and Monitor

*For use during service or repair.

Table 1-3. Specifications

GENERAL SPECIFICATIONS

Dimensions ..... 10.8 cm High x 43.2 cm Wide x 42.5 cm Long (4.25 in High x 17 in Wide x 16.75 in Long)(See Figure 1-1)

Weight
- BASIC ..... 10 kg (22 lbs)
- FULLY LOADED ..... 12 kg (26 lbs)

Operating Power
- VOLTAGE ..... 100V ac, 120V ac, 220V ac, or 240V ac (±10%)
- BASIC INSTRUMENT POWER ..... 12 watts
- FULLY LOADED POWER ..... 24 watts
- FREQUENCY ..... 47 Hz to 63 Hz (400 Hz available on request)

Warm-Up ..... 2 hours to rated accuracy

Shock and Vibration ..... Meets requirements of MIL-T-28800 for type III, class 5, style E equipment.

Temperature Range
- OPERATING ..... 0°C to 50°C
- NON-OPERATING ..... -40°C to 70°C

Humidity Range
- 0°C TO 18°C ..... 80% RH
- 18°C TO 40°C ..... 75% RH
- 40°C TO 50°C ..... 45% RH

⚠ **Maximum Terminal Voltage**
- LO TO GUARD ..... 127V rms
- GUARD TO CHASSIS ..... 500V rms
- HI SENSE TO HI SOURCE ..... 127V rms
- LO SENSE TO LO SOURCE ..... 127V rms
- HI SENSE TO LO SENSE ..... 1000V rms or 1200V dc
- HI SOURCE TO LO SOURCE ..... 280V rms

Table 1-3. Specifications (cont)

AC VOLTAGE

Input Characteristics

RANGE	FULL SCALE 5½ DIGITS	RESOLUTION		INPUT IMPEDANCE
		6½ DIGITS*	5½ DIGITS	
100 mV	125.000 mV	—	1 μV	1 MΩ
300 mV	400.000 mV	—	1 μV	
1V	1.25000V	1 μV	10 μV	±1%
3V	4.00000V	1 μV	10 μV	
10V	12.5000V	10 μV	100 μV	Shunted by
30V	40.0000V	10 μV	100 μV	
100V	125.000V	100 μV	1 mV	<180 pF
500 V	600.000V	100 μV	1 mV	

*In AVG operating mode.

Accuracy

HIGH ACCURACY MODE ±(% of Reading + Number of Counts)[1]

24 HOUR: 23°C ±1°C[2]							
RANGE	FREQUENCY IN HERTZ						
	10 TO 40*	40 TO 20k	20k TO 50k	50k TO 100k	100k TO 200k	200k TO 500k	500k TO 1M[4]
100 mV	0.08 + 0	0.02 + 5	0.04 + 5	0.2 + 0	0.6 + 0	1.5 + 0	3.5 + 0
300 mV to							
10V	0.08 + 0	0.012 + 0	0.04 + 0	0.2 + 0	0.5 + 0	1.5 + 0	3.5 + 0
30V	0.08 + 0	0.012 + 0	0.04 + 0	0.2 + 0	0.5 + 0	3.5 + 0	12 + 0
100V	0.08 + 0	0.012 + 0	0.04 + 0	0.2 + 0	1.0 + 0	3.5 + 0	—
500V[3]	0.09 + 0	0.014 + 0	0.046 + 0	0.23 + 0	—	—	—

90 day: 23°C ±5°C							
RANGE	FREQUENCY IN HERTZ						
	10 TO 40*	40 TO 20k	20k TO 50k	50k TO 100k	100k TO 200k	200k TO 500k	500k TO 1M[4]
100 mV	0.08 + 0	0.026 + 5	0.06 + 0	0.2 + 0	0.6 + 0	1.5 + 0	3.5 + 0
300 mV to	0.08 + 0						
10V	0.08 + 0	0.016 + 0	0.06 + 0	0.2 + 0	0.5 + 0	1.5 + 0	3.5 + 0
30V	0.08 + 0	0.016 + 0	0.06 + 0	0.2 + 0	0.5 + 0	3.5 + 0	12 + 0
100V	0.08 + 0	0.016 + 0	0.06 + 0	0.2 + 0	1.0 + 0	3.5 + 0	—
500V[3]	0.09 + 0	0.018 + 0	0.069 + 0	0.23 + 0	—	—	—

*With slow filter

Table 1-3. Specifications (cont)

AC VOLTAGE (cont)

Input Characteristics (cont)

>90 DAY: 23°C ±5°C ADD TO THE 90 DAY SPECIFICATION PER MONTH THE FOLLOWING % OF READING						
	FREQUENCY IN HERTZ					
ALL RANGES	10 TO 40	40 TO 20k	20k TO 50k	50k TO 100k	100k TO 200k	200k TO 500k	500k TO 1M
	0.008	0.001	0.0025	0.012	0.021	0.06	0.11

NOTES:

[1] AC coupled, 5½ digits, input level >0.25 x full scale. For 6½ digits multiply Number of Counts by 10. For input levels between 0.1 x and 0.25 x full scale, add 5 counts for the 100 mV, 1V, 10V, and 100V ranges, add 15 counts for the 300 mV, 3V, 30V ranges, and add 25 counts for the 500V range.

[2] Relative to calibration standards, within 1 hour of dc zero.

[3] Add 0.02 x (Input voltage / 600)^2 % of Reading to the specification.

[4] For input frequencies above 700 kHz, for the 300 mV and 3V ranges add 1.5% to the specification.

ENHANCED MODE: Add the following (% of Reading + Number of Counts) to the High Accuracy Mode Specifications.

RANGE	TIME SINCE FIRST READING	
	<5 MINUTES	<30 MINUTES
100 mV, 1V, 10V, 100V	0 + 0	0.003 + 4
300 mV, 3V, 30V	0 + 0	0.003 + 4
500V	0 + 0	0.003 + 6
*AC-coupled, 5½ digits, temperature change <1°C, input level >0.25 x full scale. For input levels between 0.1x and 0.25x full scale, multiply % of Reading adder by 10.		

NORMAL MODE: Add the following % of Reading to the High Accuracy Mode Specification.

SEGMENT OF SCALE	24 HOUR, 90 DAY	>90 DAY ADD PER MONTH
0.25x to 1x full scale	0.4	0.044
0.1x to 0.25x full scale	0.6	0.055

AC+DC COUPLED MODES: ±(1.1 times the ac specification for the appropriate mode + the result (Adder) from the following table).

RANGE	ADDER
100 mV to 1V	±(150 μV x (dc volts / total rms volts))
3V and 10V	±(1 mV x (dc volts / total rms volts))
30V and 100V	±(10 mV x (dc volts / total rms volts))
500V	±(50 mV x (dc volts / total rms volts))

Table 1-3. Specifications (cont)

Operating Characteristics

STABILITY: ±(1% of Reading + Number of Counts)*

RANGE	24 HOUR	90 DAY
100 mV, 1V, 10V, 100V	0.0025 + 1	0.004 + 1
300 mV, 3V, 30V	0.0025 + 3	0.004 + 4
500V	0.0025 + 5	0.004 + 6

*High Accuracy Mode, ac coupled, 5½ digits, input level >0.25x full scale, 40 Hz to 20 kHz, temperature change <1°C. For 6½ digits, multiply Number of Counts by 10. For input levels between 0.1x and 0.25x full scale, add to the Number of Counts specification 2 counts for the 100 mV, 1V, 10V, and 100V ranges, 6 counts for the 300 mV, 3V, and 30V ranges, and 10 counts for the 500V range.

CREST FACTOR ..... Up to 8:1 at full 90 day (or greater) accuracy for input signals with peaks less than two times full scale, and highest frequency components within the 3 dB bandwidth. Up to 4:1 for signals with peaks less than four times full scale, with an addition of 0.03 to the % of Reading.

3 dB BANDWIDTH ..... 3 MHz for the 100 mV range and 10 MHz for the 300 mV, 1V, 3V and 10V ranges (typical).

MAXIMUM INPUT VOLTAGE ..... ±600V rms or dc, 840V peak, or 1x 10^7 volts-hertz product.

TEMPERATURE COEFFICIENT ..... 0°C to 18°C and 28°C to 50°C
1/10 of 90 day Specification per °C

COMMON MODE REJECTION ..... >120 dB, dc to 60 hertz, with 100Ω in series with either lead.

SETTLING TIME

High Accuracy Mode ..... Sample time = 3.5 seconds
Hold time = 2.5 seconds
Measurement time = 6 seconds

If the state of the instrument is unknown, two complete measurement times will be required to guarantee a correct reading. Use of the external trigger mode will always allow a 6 second measurement time.

Enhanced Mode ..... The first reading requires the same time as the High Accuracy Mode. Subsequent readings occur every 500 milliseconds. If the input changes 1% the analog settling time to 90 Day mid-band accuracy is 1.5 seconds.

Normal Mode ..... Settling times for large changes are non-linear. Zero to Full Scale changes require 2.0 seconds to settle to 90 Day, mid-band specifications. Full scale to 1/10th full scale changes require 3.0 seconds to settle to 1/10th full scale, mid-band; 90 day specifications. Small changes (<1%) settle to mid-band specifications in <1.5 seconds.

Table 1-3. Specifications (cont)

AC VOLTAGE (cont)

Operating Characteristics (cont)

AUTORANGE POINTS

RANGE	UPRANGE	DOWNRANGE
100 mV	125.000 mV	None
300 mV	400.000 mV	110 mV
1V	1.25000V	0.352V
3V	4.00000V	1.1V
10V	12.5000V	3.52V
30V	40.0000V	11V
100V	125.000V	35.2V
500V	None	110V

OPERATING RANGE

RANGE	UNDERRANGE DISPLAY LLLLL	MINIMUM SPECIFIED LEVEL	OVERRANGE DISPLAY HHHHH
100 mV	None	12.5 mV	125.000 mV
300 mV	20 mV	40 mV	400.000 mV
1V	62.5 mV	125 mV	1.25000V
3V	200 mV	400 mV	4.00000V
10V	625 mV	1.25V	12.5000V
30V	2V	4V	40.0000V
100V	6.25V	12.5V	125.000V
500V	30V	60V	600.000V

DC VOLTAGE

Input Characteristics

RANGE	FULL SCALE 6½ DIGITS	RESOLUTION		INPUT RESISTANCE
		7½ DIGITS*	6½ DIGITS	
100 mV	200.0000 mV	—	100 nV	>10,000MΩ
1V	2.000000V	—	1 μV	>10,000MΩ
10V	20.00000V	1 μV	10 μV	>10,000MΩ
100V	128.0000V	—	100 μV	10MΩ
1000V	1200.000V	—	1 mV	10MΩ

*7½-digit resolution: In AVG operating mode.

Table 1-3. Specifications (cont)

Accuracy

DC VOLTS: ±(% of Reading + Number of Counts)				
RANGE	24-HOUR 23°C ±1°C[1]		90-DAY 23°C ±5°C	
	OPERATING MODE		OPERATING MODE	
	NORM	AVG	NORM	AVG[3]
100 mV	0.0018 + 15	0.0010 + 8	0.0025 + 40	0.0020 + 8
1V	0.0008 + 7	0.0005 + 4	0.0015 + 8	0.0012 + 6
10V	0.0006 or 6*	0.0005 or 50[2]*	0.0010 + 8	0.0008 + 60[2]
100V	0.0010 + 6	0.0005 + 5	0.0018 + 8	0.0015 + 6
1000V	0.0008 + 6	0.0005 + 5	0.0018 + 8	0.0015 + 6

*Whichever is greater

>90-Day: 23°C ±5°C

Add to the 90-day specification per month the following % of Reading and Number of Counts.

RANGE	OPERATING MODE	
	NORM	AVG[3]
100 mV	0.00017 + 5.6	0.0001 + 0.1
1V	0.0001 + 0.1	0.0001 + 0.1
10V	0.0001 + 0.1	0.00008 + 1[2]
100V	0.00013 + 0.1	0.0001 + 0.1
1000V	0.00013 + 0.1	0.0001 + 0.1

NOTES:

[1]Relative to calibration standards, 4-hour warm-up, within 1 hour of dc zero. After software calibration, add the following to the 24 hour accuracy specification:

TIME SINCE INTERNAL (HARDWARE) CALIBRATION	NUMBER OF COUNTS*
<30 Days	0
<90 Days	1
<1 Year	2
>1 Year	3

*With 6½-digit display. For 7½-digits, multiply Number of Counts by 10.

[2]7½-digit mode of operation.

[3]After 4-hour warm-up, within 1 hour of dc zero.

Table 1-3. Specifications (cont)

Operating Characteristics

TEMPERATURE COEFFICIENT: ±(% of Reading + Number of Counts)/°C

RANGE	0°C TO 18°C AND 28°C TO 50°C
100 mV	0.0003 + 5
1V	0.0003 + 1
10V	0.0002 + 0.5*
100V	0.0003 + 1
1000V	0.0003 + 0.5

*Multiply Number of Counts by 10 for AVG operating mode (7½-digit).

INPUT BIAS CURRENT

AT TIME OF ADJUSTMENT	1-YEAR 23°C ±1°C	TEMPERATURE COEFFICIENT
<±5 pA	<±30 pA	<±1 pA/°C

ZERO STABILITY ..... Less than 5 μV for 90 days after a 4-hour warm-up. Front panel ZERO push button stores a zero correction factor for each range.

MAXIMUM INPUT VOLTAGE ..... ±1200V dc or 1000V rms ac to 60 Hz, or 1400V peak above 60 Hz may be applied continuously to any dc range without permanent damage. Maximum common mode rate of voltage rise is 1000V / μsec.

ANALOG SETTLING TIME

FILTER MODE	FILTER COMMAND	TO 0.01% OF STEP CHANGE	TO 0.001% OF STEP CHANGE
Bypassed	F1	2 ms	20 ms
Fast	F0 or F3	40 ms	50 ms
Slow	F or F2	400 ms	500 ms

DIGITIZING TIME

Line Synchronous ..... For 2^0 to 2^{17} samples per reading digitizing time is from 4 ms to 9 minutes 6 seconds using a 60 Hz ac line with times increasing 20% using a 50 Hz ac line. Selectable in 18 binary steps.

Line Asynchronous ..... 2 ms. (In 3 byte binary mode with dc zero, offset, limits and calibration factors turned off.)

NOISE REJECTION

Normal Mode Rejection (for NM signals < or = 80% of range)

LINE FREQUENCY	FILTER MODE	4 SAMPLES/ READING	32 SAMPLES/ READING	128 SAMPLES/ READING
50 hertz	Fast	60 dB	70 dB	75 dB
50 hertz	Slow	85 dB	90 dB	95 dB
60 hertz	Fast	60 dB	70 dB	75 dB
60 hertz	Slow	90 dB	95 dB	100 dB

Common Mode Rejection ..... 160 dB at 60 hertz with 1 kΩ in series with either lead, and 4 samples or more per reading. Greater than or equal to 100 dB with less than 4 samples per reading.

Table 1-3. Specifications (cont)

DC RATIO

Accuracy

EXTERNAL REFERENCE VOLTAGE*	ACCURACY[1]
±20V to ±40V	±(A + B + 0.001%)
$\pm V_{min}$ to ±20V	±(A + B + (0.02% / $\lvert V_{xref} \rvert$))
*Maximum External Reference Voltage = ±40V between External Reference HI and LO terminals, providing neither terminal is greater than ±20V relative to the Sense LO or Ohms Guard[2] terminals.	

Operating Characteristics

INPUT IMPEDANCE ..... External Reference HI or LO >10,000 MΩ relative to Ohms Guard[2] or Sense LO.

BIAS CURRENT ..... External Reference HI or LO relative to Ohms Guard[2] or Sense LO <5 nA.

SOURCE IMPEDANCE ..... Resistive Unbalance (External Reference HI to LO) <4 kΩ. Total Resistance to Sense LO from either External Reference HI or LO <20 kΩ.

MAXIMUM OVERLOAD VOLTAGE ... ±180V dc or peak ac (relative to Ohms Guard[2] or Sense LO). ±300V dc or peak ac (External Reference HI to LO).

NOISE REJECTION

INPUT TERMINALS	NORMAL MODE	COMMON MODE
Sense	Same as dc volts	Same as dc volts
External Reference	line frequency and 2x line frequency >100 dB	line frequency and 2x line frequency >75 dB

RESPONSE TIME

Analog Settling Time

FILTER MODE	FILTER COMMAND	TO 0.01% OF STEP CHANGE	TO 0.001% OF STEP CHANGE
Bypassed	F1	2 ms	20 ms
Fast	F0 or F3	40 ms	50 ms
Slow	F or F2	400 ms	500 ms

NOTES: (DC Ratio)

[1]A = 10V dc range accuracy for the appropriate period of time.

B = Input signal function and range accuracy for the appropriate period of time.

V_{min} = Minimum allowable External Reference Voltage = ±0.0001V, or V_{input} /10^9 (whichever is greater).
$\lvert V_{xref} \rvert$ = Absolute value of the External Reference Voltage

[2]Ohms Guard is available through the rear input.

Table 1-3. Specifications (cont)

DC RATIO (cont)

Operating Characteristics (cont)

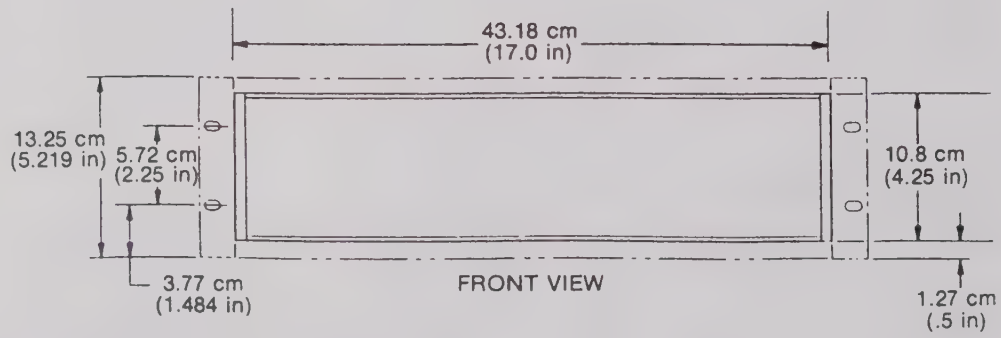
Digitizing Time	For 2^0 to 2^{17} samples per reading digitizing time is from 196 ms to 9 minutes 6 seconds using a 60 Hz ac line with times increasing 20% using a 50 Hz ac line. Selectable in 18 binary steps.
MAXIMUM RATIO DISPLAY	+1.00000 E±9

EXTERNAL TRIGGER INPUT

Polarity	May be wired internally for either rising or falling edge. Factory wired for falling edge.
High Level	+4.3V (minimum)
Low Level	+0.7V (maximum)
Pulse Width	10 μs (minimum)
Connector	BNC with the outer shell at interface common
Maximum Input	±30V
Maximum Shell to Ground Voltage	±30V

SCAN ADVANCE OUTPUT

Polarity	Positive
High Level	>+4V (TTL High)
Low Level	<+0.7V (TTL Low)
Pulse Width	3 μs (minimum)
Connector	BNC with the outer shell at interface common
Maximum Shell to Ground Voltage	±30V



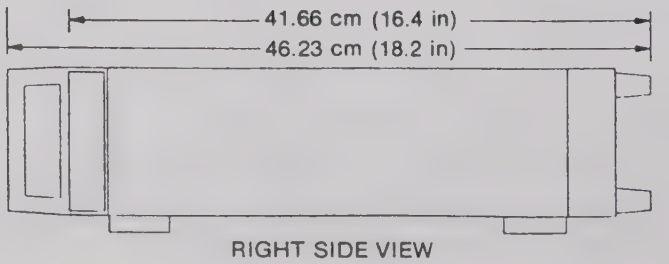


Figure 1-1. Dimension Drawing

Section 2
Operating Instructions

2-1. INTRODUCTION

2-2. Installation and operation of the multimeter are explained in this section. These instructions should be read thoroughly prior to multimeter operation. Once a familiarization with the instrument is achieved, parts of this section serve as a quick reference. Explanations and applications are provided for all standard functions and operations. For application or operation assistance or information on Fluke products, call: 800-44-FLUKE (800-443-5853) in U.S.A. and Canada, 31 40 723-220 in Europe, 206-356-5500 from other countries.

2-3. SHIPPING INFORMATION

2-4. The multimeter is packaged and shipped in a foam-packed container. Upon receipt of the instrument, a thorough inspection should be made to reveal any possible shipping damage. Special instructions for inspection and claims are included with the shipping container.

2-5. If reshipment is necessary, the original container should be used. If the original container is not available, a new container can be obtained from the Fluke Corporation. Please reference the instrument model number when requesting a new shipping container.

2-6. INSTALLATION

2-7. Non-marring feet and a tilt-down bail arrangement are installed on the instrument for field or bench use. A rack-mounting kit and rack slides are available for use with the standard 19-inch equipment racks. Information regarding installation and rack-mounting accessories is contained in Section 6.

2-8. The multimeter operates from 100, 120, 220,or 240V ac ±10% at 50 or 60 Hz.

WARNING

TO AVOID ELECTRICAL SHOCK, PROPERLY GROUND THE CHASSIS. A GROUND CONNECTION IS PROVIDED ON THE THREE-PRONG POWER CONNECTOR. IF PROPER GROUND IN YOUR POWER SYSTEM IS IN DOUBT, MAKE A SEPARATE GROUND CONNECTION TO THE REAR PANEL CHASSIS BINDING POST. OTHERWISE, THE POSSIBILITY OF ELECTRICAL SHOCK MAY EXIST IF HIGH VOLTAGE IS MEASURED WITH THE LEADS REVERSED (INPUT HI GROUNDED).

2-9. OPERATING FEATURES

2-10. Front and rear panel features are illustrated in Figure 2-1 and described in Table 2-1. Use this information for initial familiarization with the multimeter. A full explanation of all features is presented later in this section.

2-11. OPERATING NOTES

2-12. Input Power

2-13. A binding post on the rear panel has been provided as an earth ground connection. Line voltage selection (100, 120, 220, or 240V ac) is explained in Section 4. With the exception of slower reading rates and filter time-outs, operation at 50 Hz is identical to that at 60 Hz.

2-14. Fuse Location

2-15. The line fuse (0.5A MDL Slow Blow for 100 or 120V ac, or 0.25 MDL Slow Blow for 220 or 240V ac) is located on the lower right side of the rear panel (next to the power connector). The current and ohms protection fuse (1.5A AGC) is located in the lower right-hand corner of the front panel for front input connections and on the left side of the rear panel (as seen from the rear) for rear

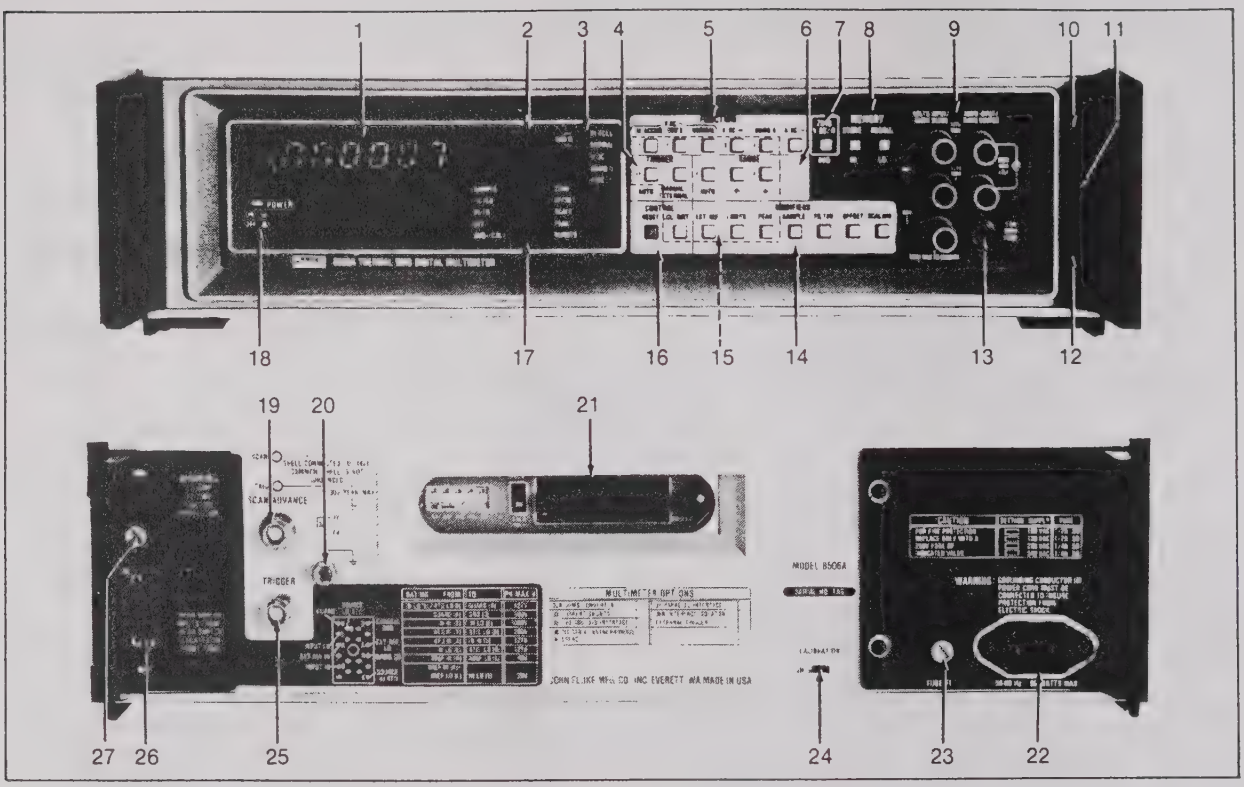


Figure 2-1. Controls, Indicators, and Connectors

Table 2-1. Controls, Indicators, and Connectors

ITEM	NAME	DESCRIPTION
1	Mantissa Field	Displays 5½, 6½, or 7½ digits with decimal point. Also displays errors, overrange warnings, underrange warnings (V AC only), prompts, numerics, recalled values, and limits indications.
2	Exponent Field	Polarity and value of exponent shown for engineering notation of display value.
3	Function Annunciators	Annunciator(s) light to indicate function selected.
4	TRIGGER Push Buttons	TRIGGER push buttons are used to select continuous (AUTO) or individual (MANUAL/EXTERNAL) measurement triggers.
5	FUNCTION Push Buttons	These buttons are used to select any of nine measurement functions: ac volts (HI ACCUR, ENH'D, NORMAL); dc volts (V DC); dc coupled ac volts (simultaneously push V DC and one of the three ac volts buttons); resistance (OHMS), or dc current (A DC).
6	RANGE Push Buttons	AUTO toggles into/out of Autoranging mode, changing range only when necessary. (Up)/(Down) push buttons exit Autoranging and increase/decrease one range with first use. Each succeeding use steps to the next higher/lower range (if available).
7	ZERO Push Button	Toggles Zero mode on and off (used in V DC and OHMS only). Each time Zero mode is toggled on, a new zero correction value is stored for the selected range and all higher ranges in the same function. The zero correction values are applied in that function while Zero mode is on. Refer to text for use during calibration.

Table 2-1. Controls, Indicators, and Connectors (cont)

ITEM	NAME	DESCRIPTION
8	MEMORY Push Buttons	STORE is used to initiate memory entry for displayed values or numeric entries RECALL commands display of a memory value HI/LO are used when storing or recalling limit values, or recalling peak values.
	Average Push Button	AVG toggles into/out of Averaging mode in V DC, OHMS, or A DC, and enables extended resolution in V AC.
9	Input Terminals	Measurement connections.
10	Guard Selector	GUARD is connected to SENSE LO when disengaged (out); GUARD is floated to allow external connection when engaged (in).
11	Ohms Selector	Push in for 4-wire ohms measurements using OHMS SENSE (HI, LO) and OHMS SOURCE (HI, LO) terminals. Push again to disengage for 2-wire ohms measurements using OHMS SENSE (HI, LO) terminals. In V AC functions, use of the 4T position is required to minimize input capacitance and attain accuracy specifications. The Ohms Selector has no effect on rear inputs.
12	Rear Input Selector	Push in to connect rear analog input terminals and disconnect front terminals. Push again to disengage, reconnecting front terminals and disconnecting rear terminals. Position of the switch can be sensed remotely.
13	Current/Ohms Fuse	Use AGC 1.5A.
14	MODIFIER Push Buttons	SAMPLE selects the number of samples-per-reading in V DC, OHMS, or A DC. (Not used in V AC). FILTER selects the filter mode. OFFSET, SCALING, EXT REF: Mathematic Operations that modify the reading value. LIMITS, PEAK: Special Operations that modify the use of the reading.
15	Numeric Push Buttons	When enabled by initially pushing the STORE button, these push buttons can be used to enter numerics, exponents, and related polarity signs.
16	CONTROL Push Buttons	RESET initiates a power-up reset. LCL/RMT usage depends on the remote interface in use: a. If the IEEE Interface (-05) is used, LCL/RMT toggles from remote to local, but not from local to remote. b. If the Bit Serial (-06) or Parallel (-07) Interface is used, LCL/RMT toggles between local and remote.
17	Status Annunciators	SAMPLE flashes to show a new reading in progress. FILTER lights whenever a slow filter is selected. AUTO lights for Autoranging. EXT lights when External Reference is enabled (disables Scaling). AVG/(CAL) lights (steady) for Averaging mode or flashes for Calibration mode. ZERO lights when Zero mode is on (V DC and OHMS only). OFFSET lights when Offset mode is enabled. SCALE lights when Scaling mode is selected (disables External Reference). PEAK lights when Peak mode is enabled. REMOTE lights when the multimeter is controlled through a remote interface.

Table 2-1. Controls, Indicators, and Connectors (cont)

ITEM	NAME	DESCRIPTION
18	POWER Switch	Push ON/push OFF. Calibration mode must be off before cycling power on or off.
19	Scan Advance Output	TTL compatible control signals to external scanner (50-ohm output impedance).
20	Chassis Ground	Binding post for ground connections.
21	Remote Interface	Connector on optional remote interface module.
22	Power Connector	Three-prong connector accepting line cord with ground wire.
23	Line Fuse	Use 1/2A Slow Blow for 100 or 120V ac, 1/4A Slow Blow for 220 or 240V ac. Refer to Fuse Replacement in Section 4.
24	Calibration Switch	Activates Calibration mode (AVG/(CAL) annunciator flashes).
25	External Trigger	Enabled by front panel MANUAL/EXTERNAL push button.
26	Rear Analog Input	Alternate connections for all front panel inputs (enabled when Rear Input Selector on front panel is pushed in). EXT REF HI and LO inputs are also included, but are not switched.
27	Rear Input Fuse	Use AGC 1.5A.

input connections. Refer to Fuse Replacement in Section 4 before replacing any fuse.

2-16. Required Hardware

2-17. The multimeter must be equipped with the following modules for standard operation (ac volts and dc volts):

1. Controller (blank display if not installed)
2. Active Filter (Error 2 if not installed)
3. A/D Converter (Error 5 if not installed)
4. Isolator (Error 9 at power-up if not installed)
5. DC Signal Conditioner (Error 9 if not installed)
6. Thermal True-RMS Converter

NOTE

The Thermal True-RMS Converter is the only ac converter that can be used in the 8506A. If another type of ac converter is installed in the 8506A, an Error E condition will be specified at power-up or reset.

2-18. Additional modules are necessary when using the multimeter in resistance or dc current functions or for remote control. The resistance and dc current modules (Options 02 and 03 respectively) cannot be installed at the same time. If it is necessary to check, install or replace modules, refer to Module Installation and Removal procedures in Section 4.

2-19. An "Error 9" indication appears in the multimeter display whenever a function is selected and the respective function module is faulty or missing. Refer to Error Codes later in this section for error descriptions and remedies. At power-up, the multimeter identifies the hardware configuration by displaying "C"and a series of alphanumerics. The Thermal True-RMS Converter is identified as "A". Optional modules are identified by the respective option number. An "8" appears in the exponent display at power-up or reset when the Isolator is installed. For example, a multimeter configured with the Current Shunts (Option 03), the IEEE Remote Interface (Option 05), and the Isolator is identified with a power-up display of "C35A 8".

2-20. Power-Up Configuration

2-21. At power initialization, or whenever the RESET button is pushed, the multimeter assumes the power-up configuration. Basically, the instrument assumes the V DC function, 1000V manual range, filter mode F0, sample factor 7, with all modes and values disabled. The power-up (or reset) configuration is fully defined in Table 2-2.

Table 2-2. Default Configurations

	POWER-UP OR RESET		SELECTION OF NEW FUNCTION (1)	
	CONDITION	DISPLAY	CONDITION	DISPLAY
Function	DC Volts	V DC on	New Function	VDC,VAC,ADC,or OHMS on
Range	1000V Manual	AUTO off	Autoranging	AUTO on
Trigger	Auto	SAMPLE flashes	Retains Previous Trigger Mode	SAMPLE flashing or off
Filter	F0	FILTER off	See Notes 2,3 and chart	FILTER on or off
Sample	7	SAMPLE flashes	See Note 3 and chart	SAMPLE flashes
Offset	Off, Value 0	OFFSET off	Off, retains value	OFFSET off
Scaling	Off, Value 1	SCALE off	Off, retains value	SCALE off
External Reference	Off, Note 4	EXT REF off	Off, retains last value	EXT REF off
Limits	Off, Value 0	Normal Display	Off, retains value	Normal Display
Peak	Off	PEAK off	Off, retains last values	PEAK off
Averaging	Off	AVG/(CAL) not on steady	Off (3)	AVG/(CAL) not on steady
Zero	On, Value 0	ZERO on	Retains mode values and state (5)	ZERO on (VDC,OHMS) or off
Calibration Mode	Note 5		Note 5	

Notes:

1. Re-selection of the same function sets autoranging (AUTO on), but retains all other mode values and states.

2. In VAC functions, only filter modes F and F0 are allowed. In VDC, OHMS, or ADC, filter modes F, F0, F1, F2, and F3 are allowed.

3. Averaging mode is available in VDC, OHMS, and ADC only. The AVG button can also be used in VAC functions to command extended resolution only. If Averaging mode was in effect, selecting VDC, OHMS, or ADC sets filter mode F0 and sample setting 7. If VDC, OHMS, or ADC is re-selected without changing the function, the state of Average mode is not changed, and the existing filter mode and sample setting are retained.

4. The External Reference value is initialized to the multimeter software number whenever power-up or reset occurs. RECALL EXT REF can then be used to display this number. Any subsequent activation of External Reference mode replaces the software number with the actual external reference value. While in VAC functions, EXT REF cannot be used to either recall the software number or activate External Reference mode.

5. The Calibration mode state is on or off solely dependent on the position of the rear panel Calibration Switch. Do not cycle power on or off with this switch ON.

FROM:	TO: VAC	VDC OHMS ADC
VAC	——— X	If manual ranging, retains manual ranging and previous range. If autoranging, retains autoranging beginning at previous range. Filter mode retained.
	——————— X	Autoranging Begins at highest range (1000V, 100 Megohms, or 1A) Retains previous filter mode (F or F0) Sample factor 7
VDC OHMS ADC	——— X	Autoranging Begins at r500 Filter mode off (F0)
	——————— X	Autoranging Begins at highest range (1000V, 100 Megohms, or 1A) Retains previous filter mode (F, F0, F1, F2, or F3) Retains previous sample factor

2-22. Display

2-23. MEASUREMENT READING

2-24. The measurement display consists of mantissa and exponent fields. The mantissa presents polarity, 5-1/2, 6-1/2 or 7-1/2 digit resolution (range and function dependent) and automatic decimal placement. In addition, the mantissa displays range identifiers (V AC only), numeric storing entries, recalled values, error and warning information, and interactive programming information (prompts).

2-25. When very large or small readings are displayed, the exponent field is also used to maintain maximum resolution. A negative exponent field polarity indicates multiplication of the mantissa by the displayed power of ten (–3 means .001). A positive exponent field polarity indicates multiplication of the mantissa (+3 means 1000). Exponent values of –6, –3, +3, or +6 are available for displayed readings. Additional exponents of –9 or +9 are displayed when storing offset or scaling factors entered with the front panel push buttons.

2-26. The measurement display is altered when the Average mode or the Limits mode is enabled. When the Average mode is enabled (AVG/(CAL) annunciator on), an extra digit of resolution is provided in the V DC, A DC, and OHMS functions for certain ranges: In V DC, 6-½ digits are displayed for all ranges except the 10V range, for which 7-½ digits are displayed (the 7th digit is displayed in the exponent field); in A DC and OHMS, 6-½ digits are displayed for all ranges. The Average mode is not available in the V AC functions, but the AVG push button can still be used to enable extended resolution. Resolution in each range and function is summarized in Table 2-3. When the Limits mode is enabled, the display indicates HI, LO, or PASS instead of a numeric reading.

NOTE

When the Average mode is enabled in the 10V dc range, the exponent field displays the seventh mantissa digit and does not indicate the reading's exponent. In this case, the reading's decade multiplier cannot be interpreted from the display if a math function (such as offset or scaling) is enabled.

2-27. ANNUNCIATORS

2-28. Selecting a valid function causes the respective annunciator(s) to light. One annunciator lights if ac volts high accuracy (HI ACCUR), ac volts normal (NORMAL), dc volts (V DC), resistance (OHMS), or dc current (A DC) is selected. Two annunciators light if ac volts enhanced (ENH'D) or ac volts normal (or high accuracy) and dc coupled ac volts (HI ACCUR + V DC, or NORMAL + V DC) are selected. Three annunciators light when dc coupled ac volts enhanced (ENH'D + V DC) is selected. Ordinarily, the V DC annunciator lights in the power-up or reset configuration.

2-29. Status annunciators light to signify various modes of operation. Annunciators (as defined in parentheses) light when any of the following modes are enabled: Peak (PEAK), Scaling (SCALE), or External Reference (EXT), Averaging (AVG), Offset (OFFSET), Autoranging (AUTO), or V DC/Ohms Zero (ZERO). The FILTER annunciator lights (steadily) whenever the slow filter is selected (filter on mode in V AC). With a distinctive display of HI, LO, or PASS, the Limits mode requires no separate status annunciator.

2-30. The SAMPLE annunciator blinks to signify a new reading in progress. Depending on the function selected, two response patterns are available. If the multimeter is in one of the ac volts functions (NORMAL, HI ACCUR, or ENH'D), SAMPLE blinks at predetermined rates. AC Volts High Accuracy causes SAMPLE to blink on once every six seconds. AC Volts Normal causes SAMPLE to blink on once every 0.5 second. AC Volts Enhanced causes SAMPLE to blink on once as an initial high accuracy reading is taken, then (after six seconds) to continue blinking once every 0.5 second.

2-31. When the multimeter is set for dc volts, resistance, or dc current functions, the SAMPLE annunciator flashes at the reading (display update) rate for sample settings from 0 through 7. The flash rate for sample settings 0, 1, and 2 is very rapid and causes the SAMPLE annunciator to appear to be steadily lighted. For sample settings from 8 through 17, the SAMPLE annunciator flashes at the sample setting 7 rate only. Since these higher sample settings may require considerable time for a display update, this feature is necessary to insure that the operator is aware of a reading in progress.

2-32. RANGE IDENTIFIER

2-33. The multimeter momentarily displays a range identifier whenever a V AC function is selected and when a new range is selected in a V AC function. For example, r500 is displayed when a V AC function is selected (and the previous function was V DC, A DC, or OHMS). When changing from one V AC function to another, the previously enabled range is retained and momentarily displayed. The appropriate range identifier is displayed for any subsequent range change (whether the instrument is in auto or manual ranging). The range can be verified at any time by reselecting the same V AC function. This action causes no change in the multimeter, other than a momentary interruption of measurements (during which the range identifier is displayed). In V DC, A DC, and OHMS functions, the range is identified by the position of the decimal point.

2-34. OVERRANGE INDICATION

NOTE

The accuracy of a VAC reading is a function of the input level. Therefore, accuracy is specified within the minimum and overrange input levels defined in Table 2-4. VAC inputs outside this range are not displayed.

Table 2-3. Display

The reading (with decimal point) is displayed as shown in each function and range. The use of mathematic operations (SCALING or EXT REF and OFFSET) may alter these patterns. The use of LIMITS causes a display of HI, LO, or PASS.

RANGE IDENTIFIER*		DISPLAY MANTISSA[1]	DISPLAY EXPONENT
V AC	r100 (-3)	188.888	-3
	r300 (-3)	888.888	-3
	r1	1.88888	
	r3	8.88888	
	r10	18.8888	
	r30	88.8888	
	r100	188.888	
	r500	888.888	

		DISPLAY MANTISSA[2]	DISPLAY EXPONENT
V DC	100 mV	±888.8888	-3
	1V	±8.888888	
	10V	±88.8888	
	100V	±888.8888	
	1000V	±8888.888	
OHMS	10Ω	88.8888	
	100Ω	888.888	
	1 kΩ	8.888888	÷3
	10 kΩ	88.88888	÷3
	100 kΩ	888.8888	÷3
	1 MΩ	8.88888	÷6
	10 MΩ	88.8.8.8	÷6
	100 MΩ	888.888	÷6
A DC	100 μA	±888.888	-6
	1 mA	±8.88888	-3
	10 mA	±88.8888	-3
	100 mA	±888.888	-3
	1A	±8.88888	

NOTES:
1. Additional digit in V AC extended resolution is shown in lighter print.
2. Additional digit in Averaging mode is shown in lighter print.
3. In the 10V dc range, the exponent is used to display an additional mantissa digit when Averaging mode is selected.

Table 2-4. Operating Range

V AC

RANGE	UNDERRANGE (LLLLLL)	MINIMUM SPECIFIED LEVEL	OVERRANGE (HHHHHH)
100 mV	None	12.5 mV	125 mV
300 mV	20 mV	40 mV	400 mV
1V	62.5 mV	125 mV	1.25V
3V	200 mV	400 mV	4V
10V	625 mV	1.25V	12.5V
30V	2V	4V	40V
100V	6.25V	12.5V	125V
500V	30V	60V	600V

V DC

RANGE	OVERRANGE (HHHHHH)
100 mV	200 mV
1V	2V
10V	20V
100V	128V
1000V	1200V

A DC

RANGE	OVERRANGE (HHHHHH)
100 μA	250 μA
1 mA	2 mA
10 mA	16 mA
100 mA	128 mA
1A	1.28A

OHMS

RANGE	OVERRANGE (HHHHHH)
10Ω	20Ω
100Ω	200Ω
1 kΩ	2 kΩ
10 kΩ	25 kΩ
100 kΩ	250 kΩ
1 MΩ	4.1 MΩ
10 MΩ	35 MΩ
100 MΩ	265 MΩ

2-35. The measurement display presents a distinct indication when overrange inputs are detected in any function. An input voltage exceeding the full scale value for the range selected causes a display of HHHHHH. In V AC functions, full scale values approximate maximum specified levels (as required to maintain accuracy). The overrange indication therefore also serves as an upper accuracy limit indication.

2-36. LOW INPUT INDICATION

2-37. In the V AC functions, the multimeter notifies the user if the input level is too low to maintain specified reading accuracy. If a V AC function is selected, the multimeter displays LLLLLL whenever the input voltage is less than approximately 5% of full scale. The only exception is the 100 mV ac range, which has no under-range limit.

2-38. WARNING INDICATION

2-39. When in the Scaling, External Reference, Offset or Limits mode, there may be no readily discernible display of the true measurement value. In these modes of operation, the multimeter provides a distinctive display when the voltage is 30V or higher at the front panel input connections. If this voltage exceeds the overload point for the range in use, the Overrange Indication (flashing HHHHHH) is displayed. If this voltage does not exceed the range overload point, a single H is flashed in the exponent display.

NOTE

Flashing indicators in the digit or exponent display are a warning only; they have no effect on instrument operation.

2-40. ERROR CODES

2-41. Error codes offer considerable help in identifying improper procedures or equipment configurations. These codes are explained in Table 2-5.

Table 2-5. Error Codes

MOMENTARY ERROR CONDITIONS

(The reading in progress is aborted, but multimeter operation is automatically restored with the next trigger. The function annunciator remains on during a momentary error condition.)

CODE	FAULT	SOLUTION
Error 0	V DC/Ohm Zero, zero attempted in wrong function (not V DC or OHMS) or an overrange has been entered.	Check function. Only V DC or OHMS are permissible.
Error 1	Store attempted during overrange condition.	Change to higher range, or (if storing cal correction factors) use lower value source.
Error 6	Display overflow error.	Check offset and scaling values.
Error 7	External Reference error - voltage on one input exceeds 20V dc.	Revise external reference input.
Error 8	Controller module is faulty.	Power off: replace Controller module.
Error A	Illegal push button usage in any of the three V AC modes.	Use correct button(s).
Error b	Illegal push button sequence in Calibration mode.	Wait till display clears. Use correct sequence.
Error C	Invalid push button sequence, or illegal value entered.	Wait till display clears. Use correct sequence or value within limits.
Error d	Calibration Memory chip faulty or not installed. Occurs when storing into, or recalling from, Calibration Memory.	Replace or install Calibration Memory chip.
Error F	Cal Memory check-sum problem.	Try new power-up. If necessary, reprogram Cal Memory. Replacement of Calibration Memory may be necessary.
Error H	Ohms connection problem.	Verify proper connections. Check input protection fuses.

LATCHING ERROR CONDITIONS

(A valid function must be selected to restore multimeter operation. All function annunciators are off during a latching error condition.)

Error	System error, usually appears at power-up or reset.	Repeat power-up or reset.
Error 2	Filter module faulty or not installed.	Power off; replace or install filter module.
Error 3	DC Signal Conditioner module faulty or not installed.	Power off; replace or install DC Signal Conditioner module.
Error 4	OHMS, or A DC error.	Check for improper input level. Check function causing error indication. Applicable module may need replacement or installation.
Error 5	Analog to Digital Converter Module error.	Power off; replace or install Analog to Digital Converter module.
Error 9	Function selection error. The function module selected is faulty or not installed. V DC problem causes Error 3.	Push RESET to clear error condition.
Error E	At power-up or reset only, an unallowed ac converter is installed or the Calibration Memory module is installed.	Power off, remove the unallowed ac converter or the Calibration Memory module. The Thermal True RMS Converter is the only ac converter allowed in the 8506A. The Calibration Memory is a standard part of the controller.

2-42. INTERACTIVE PROGRAMMING INFORMATION

2-43. The multimeter displays prompting messages during STORE and RECALL operations. Whenever the STORE button is pushed, the display responds with "?". The operator may now designate either the displayed value or keystroked numerics as the programming entry. If the displayed reading is being stored, pushing the appropriate terminator button (SCALING, HI OR LO for limits, or OFFSET) completes the operation. The multimeter adopts both the mode specified with the terminator and the value previously displayed. If keystroked numerics are being stored, the multimeter displays the digits as they are entered from the front panel. Once all numbers for a particular mode are entered, the appropriate terminator button (SCALING, HI, LO, OFFSET) is pushed. With V DC, OHMS, or A DC functions, keystroked numerics can be used to enter the filter mode and sample factor. When either the displayed value or keystroked numerics have been entered, the display resumes the measurement reading function (or HI, LO, PASS in the Limits mode) when the terminator button is pushed.

2-44. The RECALL button commands a display of a stored factor or value. The procedure requires the following two steps when recalling the offset value, the scaling factor, the filter mode, the sample setting, or the zero value:

1. Push the RECALL button (display responds with "?").

2. Push the appropriate terminator button (OFFSET, SCALING, FILTER, SAMPLE or ZERO). The respective value is displayed as long as the terminator button is held depressed. Once the terminator button is released, the multimeter resumes operation; no mode or value is changed.

2-45. Three push button steps are required to recall a limit or peak value. First press RECALL ("?"). Then specify whether upper or lower limit or peak is desired by pressing HI or LO (display responds with "YES?"). Finally, push the appropriate terminator button (LIMITS or PEAK).

2-46. Front Panel Push Buttons

2-47. The multimeter employs 26 color-coded push buttons on the front panel. Most of the push buttons control more than one function. For example, many mode control push buttons also serve as numeric entry push buttons when used during a store operation. The number of keystrokes required for any operation is kept to a minimum. Refer to Figure 2-2 for a description of each push button and, where applicable, examples of typical programming operations.

2-48. Operation of the multimeter is straightforward. Preset measurement configurations are made at power-up, reset, or function selection. Programmed values are retained whenever the range or function is changed. Desired mode changes are made independently following a programming hierarchy of:

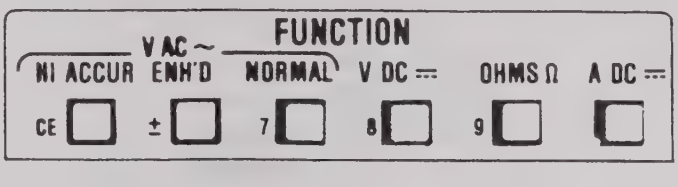
1. Measurement Parameters
2. Mathematic Operations
3. Special Operations

2-49. Measurement parameters define operations that affect the resolution, stability, and accuracy of the reading. Depending on the function selected, a specific set of parameters is available. In V AC functions (HI ACCUR, ENH'D, NORMAL), range, filter, extended resolution, and trigger may be specified. In V DC, OHMS, and A DC functions, range, filter, trigger, sample, and averaging may be specified. The Zero operation can be performed in the V DC and OHMS functions only.

2-50. Mathematic operations (External Reference or Scaling, Offset) alter the reading to operator requirements. For example, when Offset is used, only the difference between the reading and the offset value is displayed. External Reference may not be used in V AC functions.

2-51. Special operations (LIMITS, PEAK) specify how the reading is used. For example, Peak mode can be used to continuously update a record of the highest and lowest readings, and/or Limits mode may be used for a HI, LO, or PASS display of the measurement reading. A comprehensive setup routine is summarized in Figure 2-3. All or part of this routine can be used to establish or change measurement parameters, mathematic operations, or special operations.

2-52. Use the push buttons in a steady and methodical manner when programming the multimeter. Error codes usually identify any programming problem and specify a solution (refer to Table 2-5). A numeric entry may be aborted at any time prior to termination by pushing the CE button. The multimeter responds by displaying "?": another numeric entry may now be made, or the displayed value may be stored by pushing the desired terminator button. A store or recall operation may be entirely aborted prior to execution by pressing STORE or RECALL a second time. The multimeter reverts to its state prior to the store or recall once a momentary Error C condition elapses.



The FUNCTION push buttons allow selection of the analog measurement function. Standard functions include: ac volts (NORMAL, ENH'D, HI ACCUR) and dc volts (V DC). Optional functions include resistance (OHMS) and current (A DC).

HI ACCUR

Push HI ACCUR for maximum ac volts accuracy with six second reading times. Eight ranges are available (100 mV, 300 mV, 1V, 3V, 10V, 30V, 100V, 500V). Standard resolution is 5½ digits on all ranges. Extended resolution (6½ digits) is available when the AVG button is pushed.

ENH'D

Push ENH'D for an initial HI ACCUR measurement, which is used to correct subsequent measurements made at NORMAL mode speed. The same eight ranges are available. Extended resolution (6½ digits) is available when the AVG button is pushed.

NORMAL

Push NORMAL for somewhat reduced ac volts accuracy, but with fast reading times. The same eight ranges are available. Extended resolution (6½ digits) is available when the AVG button is pushed.

V DC

Push V DC for dc voltage measurements with 6½ digit resolution on five ranges (100 mV, 1V, 10V, 100V, 1000V).

OHMS

Push OHMS to make resistance measurements with 5½ or 6½ digit resolution on eight ranges (10 ohms, 100 ohms, 1 kilohm, 10 kilohms, 100 kilohms, 1 Megohm, 10 Megohms, 100 Megohms). The Ohms Converter module (Option 02) must be installed.

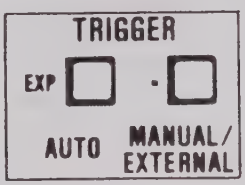
NOTE

Either two-wire or four-wire resistance measurements can be made. Refer to Measurement Terminals and Controls.

A DC

Push A DC for dc current measurements with 5½ digit resolution on five ranges (100 μA, 1 mA, 10 mA, 100 mA, 1A). The Current Shunts module (Option 03) must be installed.

Figure 2-2. Front Panel Push Buttons

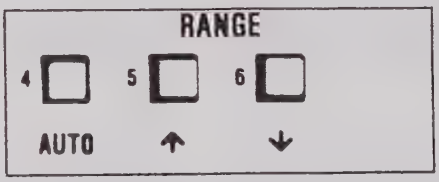


AUTO

The AUTO (trigger) push button selects the Auto Trigger mode. A flashing SAMPLE annunciator verifies Auto Trigger operation.

MANUAL/ EXTERNAL

If used in Auto Trigger mode, the MANUAL/EXTERNAL push button disables the Auto Trigger mode (SAMPLE annunciator stops flashing), enables the front panel Manual Triggering mode, and arms the External Triggering mode. If used in Manual Trigger mode, the MANUAL/EXTERNAL push button triggers a new measurement: any reading already in progress is aborted and the new reading begun immediately. The display, once updated, is held until the next manual trigger. An external trigger applied through the rear panel external trigger jack similarly commands a new reading. An external trigger applied simultaneously with a front panel manual trigger will be ignored. AUTO must be pushed to reenter the Auto Triggering mode.



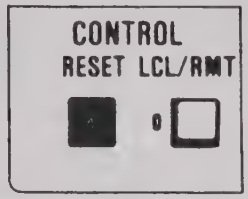
AUTO

AUTO RANGE toggles into/out of the Autoranging mode, changing the existing range if necessary. The AUTO annunciator lights when Autoranging is selected.

Each use of this manual ranging push button selects the next higher available range. If AUTO was previously activated, use of the up-range push button toggles out of Autoranging (AUTO annunciator off) and steps to the next higher range. No range change is effected if the multimeter is already in the highest range.

Use of the down-range push button causes the multimeter to toggle out of Autoranging (AUTO annunciator off) and assume the next lower available range. Each successive use of the down-range button selects the next lower range. No range change is effected if the multimeter is already in the lowest range.

Figure 2-2. Front Panel Push Buttons (cont)



RESET

The RESET push button is powerful: all modes and stored values (other than calibration factors) are lost if RESET is pressed. Once RESET is used, the multimeter assumes the Power-Up configuration (without actual power loss).

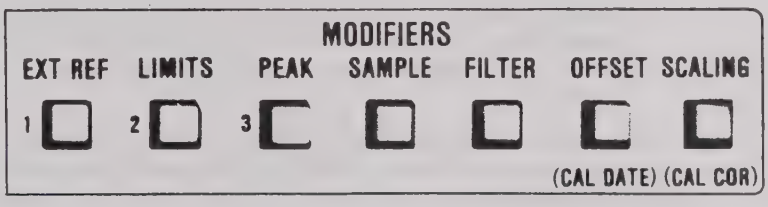
LCL/RMT

Depending on the remote interface being used, pushing the LCL/RMT button may cause one of three multimeter responses.

1.) If the IEEE Interface (Option 05) is installed, LCL/RMT can be used to command local control only if the multimeter is already in remote control. LCL/RMT cannot command remote control.

2.) If the Bit Serial Interface (Option 06) or the Parallel Interface (Option 07) is installed, LCL/RMT can be used to alternately select local or remote control.

3.) If no remote interface is installed, use of LCL/RMT causes a latching error condition.



EXT REF

The EXT REF button toggles into/out of the External Reference mode in V DC, OHMS, and A DC functions only. Either External Reference or Scaling may be enabled: selection of one mode disables the other. After power-up or reset, RECALL EXT REF can be used to identify the software version.

NOTE

The external reference voltage, applied through the rear input connector, is displayed as long as EXT REF is held depressed.

LIMITS

The LIMITS push button toggles into/out of the Limits mode without changing stored limits values. A display of HI, LO, or PASS denotes use of the Limits mode.

PEAK

The PEAK push button toggles into/out of the Peak mode. While in the Peak mode (PEAK annunciator lighted), a continuously updated record of the highest and lowest reading values is stored. These values are also held in memory after the mode is disabled. Reentry into the Peak mode causes previously recorded values to be erased and a new series of peak values to be stored.

Figure 2-2. Front Panel Push Buttons (cont)

SAMPLE

If the dc volts (V DC), resistance (OHMS), or dc current (A DC) function is selected, SAMPLE can be used to select the number of samples to be averaged for each display update. SAMPLE cannot be used in V AC functions.

FILTER

AC Volts functions normally use filter mode F0. The filter can be selected for these functions (if the input frequency is less than 40 Hz) by pushing FILTER. The accuracy of the instrument is degraded if the filter is selected for higher input frequencies.

If V DC, A DC, or OHMS is selected, FILTER can be used to toggle between the slow filter (mode F - FILTER annunciator on) and the fast filter (F0 - FILTER annunciator off). Alternately, any of five combinations of filter and timeouts can be selected as programmed numerics.

OFFSET

The OFFSET push button can be used to toggle into/out of the Offset mode (OFFSET annunciator lights). Two methods are available for simultaneously entering an offset value and activating the Offset mode.

1.) A numeric value may be entered using a store sequence. For example, store an offset of 1.25 as follows:

STORE 1 . 2 5 OFFSET

2.) A displayed reading can be stored as the offset value. Use the following sequence:

STORE OFFSET

NOTE

In some instances, the displayed value may not be an appropriate offset value. For example, if the displayed value is being used to zero the multimeter, it is important to verify that no other mathematic operations are in effect. In such a case, check that OFFSET, SCALING, and EXT REF annunciators are all off before storing a new offset value.

(CAL DATE)

When the multimeter is in the Calibration mode (AVG/(CAL) annunciator flashes), the (CAL DATE) push button is used to enter six digits which either denote the date or identify the multimeter by number. These digits may be recalled at any time.

SCALING

The SCALING push button can be used to toggle into/out of the Scaling mode without affecting any scaling value already stored. Either of the following two methods can be used to store a new scaling factor and enable the Scaling mode:

1.) Use the following sequence to store the display as a scaling factor:

STORE SCALING

2.) Numeric entry scaling values may be programmed using the following procedure:

STORE (numerics) SCALING

With either method, the Scaling mode is entered with the initial use of the SCALING button.

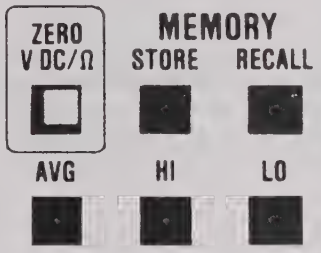
NOTE

Verify that the displayed value is the desired scaling value. Any mathematic operations (SCALING, EXT REF, OFFSET) already in effect must be cancelled if the actual measurement is desired as the scaling value. To cancel any of these modes, toggle SCALING, EXT REF, or OFFSET and verify that the respective annunciators are dark.

Figure 2-2. Front Panel Push Buttons (cont)

(CAL COR)

With the multimeter in Calibration mode, calibration correction factors can be entered for each range in V DC, OHMS, and A DC functions. Correction factors can also be stored at a frequency of interest in V AC functions. Correction factors are automatically applied to the uncorrected reading. Uncorrected readings can be recalled when the Calibration mode is either enabled or disabled. Refer to Calibration Mode later in this section.



STORE

STORE is used as a first step in programming certain measurement parameters, mathematic operations, or special operations. STORE is the only push button that can activate the numeric entry keys. The multimeter prompts the second step by displaying "?". Following is a list of STORE operations:

Measurement Parameters (for V DC, OHMS, A DC only):

STORE { 0 - 17 — SAMPLE
STORE { 0,1,2,3 or no key — FILTER

Mathematic Operations:

To store the displayed value as an offset or scaling value and enter the respective mode:

STORE { OFFSET / SCALING

To store a numeric entry as an offset or scaling value and enter the respective mode:

STORE (numerics) { OFFSET / SCALING

Special Operations:

To store the displayed value as a high or low limit and enter the Limits mode:

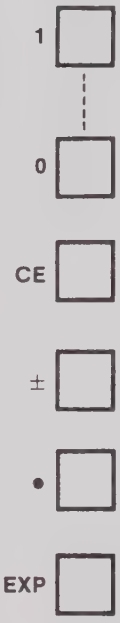
STORE { HI / LO

To store a numeric entry as a high or low limit and enter the Limits mode:

STORE (numerics) { HI / LO

Figure 2-2. Front Panel Push Buttons (cont)

The multimeter utilizes fourteen dual purpose push buttons as numeric entry keys. When programming sample settings or filter modes, a one- or two-digit entry is necessary. When programming limits, or scaling and offset values, a longer entry may be required. Use the following sequence:



Mantissa Field: Enter up to seven digits, with decimal point. Toggle polarity (±) button as required.

Exponent Field: Push EXP button, then enter a single digit exponent. Toggle the polarity button again to set the exponent polarity.

Use the CE push button at any time prior to the terminator (last button in a store numeric sequence) to clear all numerics and revert to a "?" display. Fresh numerics may then be entered immediately.

The RECALL push button can be pressed to recall and display values stored in the Limits, Peak, Scaling, Offset, Zero, External Reference, (V DC, OHMS, A DC functions only), Sample or Filter modes. For recall of uncorrected readings, or calibration dates, refer to Calibration Mode later in this section. No stored value is affected during the RECALL operation. The recalled value will be displayed as long as the last push button in the sequence is held depressed.

To recall measurement parameters:

RECALL → { SAMPLE, FILTER }

To recall mathematic operation values:

RECALL → { OFFSET, SCALING, EXT REF (not in V AC), V DC/OHMS ZERO }

To recall a special operation value:

RECALL → { HI, LO } → { LIMITS, PEAK }

Figure 2-2. Front Panel Push Buttons (cont)

ZERO VDC/Ω

The ZERO push button can be used to zero any offsets in the V DC and OHMS functions. To zero the offsets for a particular range, proceed as follows:

1. Select the V DC or OHMS function and select the desired range.

2. Short INPUT HI and LO. If in OHMS, select the two-terminal configuration or also short SENSE HI and LO. (To zero the multimeter's internal offsets, short the inputs with a high-quality, low-thermal shorting bar. To also zero the offsets in the external test system, short the inputs with the test leads instead.)

3. Press ZERO (the ZERO annunciator will light). The zero correction remains in effect until ZERO is pressed again or a function other than V DC or OHMS is selected (the ZERO annunciator will turn off).

A new zero correction is stored each time the ZERO annunciator is toggled on. The multimeter uses the same zero for all higher ranges in the same function. A separate zero may be stored for each range. (Start with the lower ranges so that later zeros do not overwrite previous zeros.) Zero correction factors are reset to 0 at reset or power-up. Appendix 7B explains how the ZERO push button is used in Calibration mode.

AVG

The AVG push button can be used to optimize sample and filter factors for each range in V DC, OHMS, and A DC functions only. In V AC functions, Average mode is not available, but the AVG button can be used to command an extra digit of resolution on most ranges.

HI

LO

The HI and LO push buttons are used to store or recall limit values and for recall only of peak values. Refer to STORE and RECALL push button descriptions for the applicable sequence.

Figure 2-2. Front Panel Push Buttons (cont)

If multiple programming steps are required, use the sequence presented here as a general guide. Use the push button(s) shown for the action described.

INITIALIZATION

CONFIGURATION AT POWER-UP OR RESET (V DC, 1000V, manual range, auto trigger, filter mode F0, zero mode on, no other modes or values). Calibration mode must be off before power-up.

STEP	ACTION	PUSH BUTTONS
1	FUNCTION selection V AC	V AC HI ACCUR, V AC ENH'D
	a. Selecting any V AC function sets autorange, filter mode F0.	
	b. Push V AC HI ACCUR, V AC ENH'D, or V AC NORMAL and V DC simultaneously for dc-coupled ac measurements.	V AC NORMAL

Figure 2-3. Programming Hierarchy

2 FUNCTION selection (V DC, OHMS, A DC)

V DC

OHMS

a. If previous function was V AC, the following conditions are set:
- Autoranging
- Filter mode retained
- Sample factor 7
- All mathematic and special operations values retained, modes disabled

A DC

b. If previous function was V DC, OHMS, or A DC, the following conditions are set:
- Autoranging
- Previous filter mode retained
- Previous sample factor retained
- All mathematic and special operations values retained, modes disabled
- Previous trigger mode retained

MEASUREMENT PARAMETERS

Measurement parameters establish reading resolution, noise rejection, stability and accuracy.

3 TRIGGER selection

a. If in manual, change to auto

AUTO

b. If in AUTO, change to manual

MANUAL/ EXTERNAL

c. Manual triggers

MANUAL/ EXTERNAL → MANUAL/ EXTERNAL

4 RANGE selection

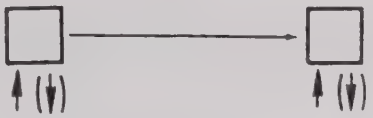
a. Toggle into/out of autoranging

AUTO ↔ AUTO

Figure 2-3. Programming Hierarchy (cont)

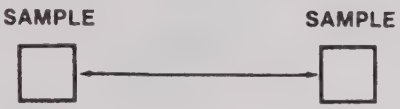
b. Select manual ranging, step to next higher, (lower) range.

c. Continue stepping to available higher, (lower) ranges.



5 Reading Rate Selection (V DC, OHMS, A DC only)

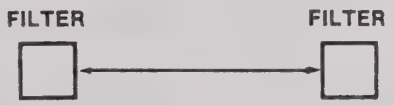
a. Toggle between sample settings 5 (2 exp 5 = 32) and 7 (2 exp 7 = 128)



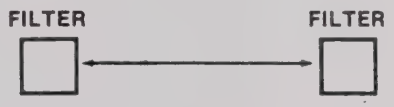
b. Select any sample setting from 0 (2 exp 0 = 1) to 17 (2 exp 17 = 131,072)

6 FILTER selection

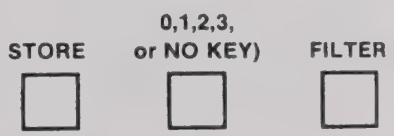
a. V AC functions only: toggle between filter mode F0 and F



b. V DC, OHMS, A DC only: toggle between slow filter (F) and fast filter (F0).



c. V DC, OHMS, A DC only: select filter F, F0, F1, F2, or F3.



7 V DC, OHMS, A DC only: toggle the Averaging mode on or off. In V AC, enables extended resolution.

8 V DC/OHMS Zero: toggle on/off (V DC or OHMS only). New zero stored each time Zero mode is enabled. Refer to Appendix 7B for use with Calibration mode.

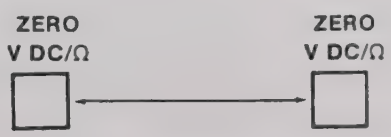


Figure 2-3. Programming Hierarchy (cont)

MATHEMATIC OPERATIONS

Stop here if only a direct measurement reading is desired. Further steps yield ratio, deviation, percentage variation and other special readings.

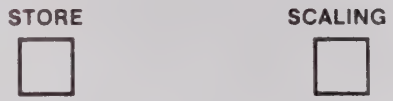
Refer to Applications in this Section for examples.

NOTE

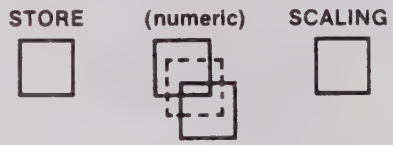
Scaling (or External Reference) is applied first. The result of this operation is then offset.

9 SCALING selection (disables External Reference)

a. Store displayed value, enter Scaling mode

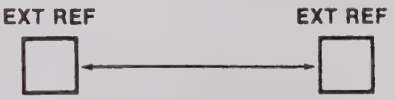


b. Store numeric value (non-zero), enter Scaling mode.



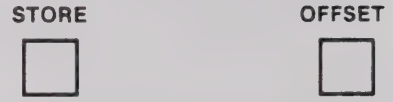
c. Toggle into/out of Scaling mode while retaining value.

10 External Reference selection (disables Scaling) — toggle on/off. Not available in V AC functions.

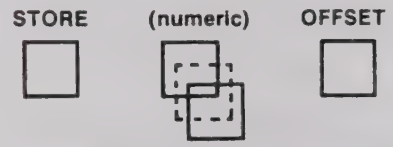


11 OFFSET selection

a. Store displayed value, enter Offset mode



b. Store numeric value, enter Offset mode



c. Toggle into/out of Offset mode while retaining value.

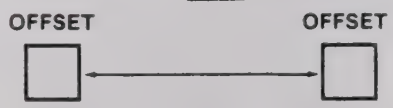


Figure 2-3. Programming Hierarchy (cont)

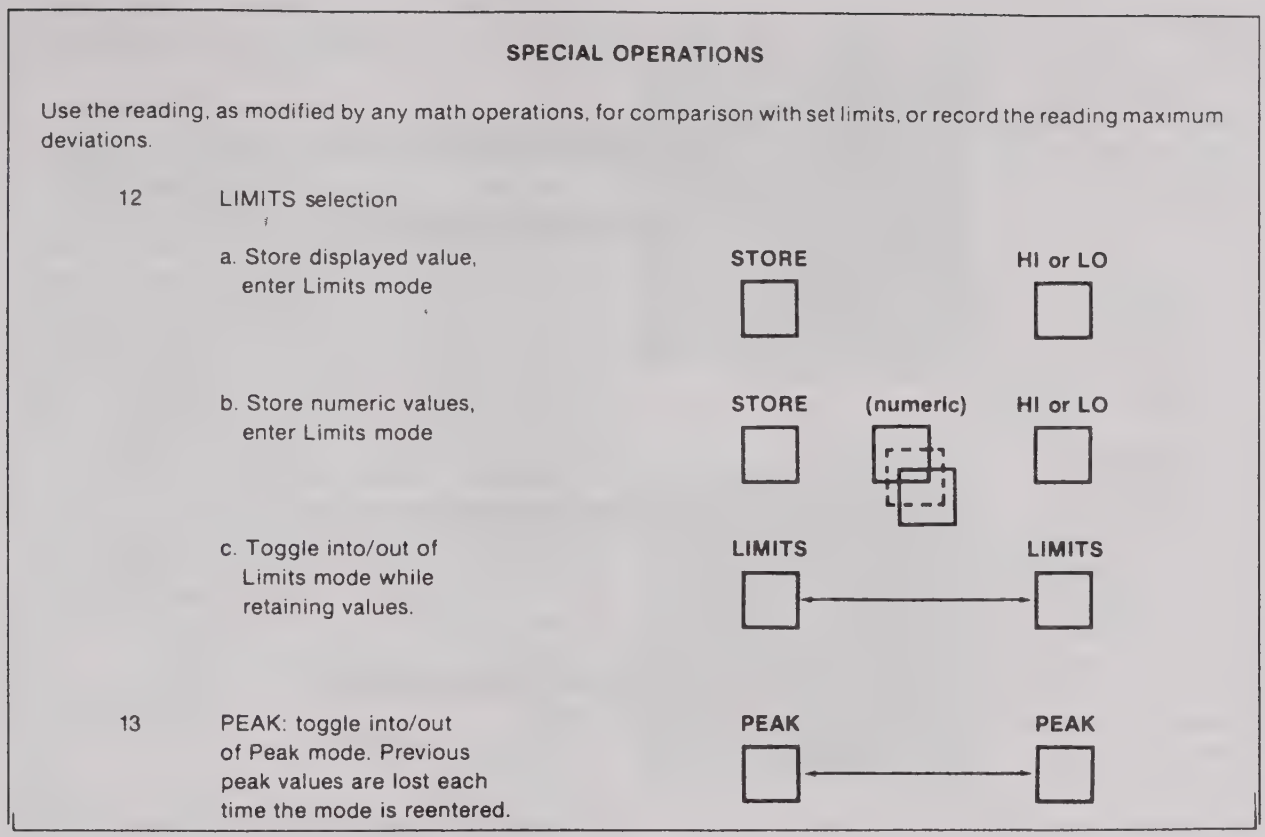

SPECIAL OPERATIONS
Use the reading, as modified by any math operations, for comparison with set limits, or record the reading maximum deviations.
12
LIMITS selection
a. Store displayed value, enter Limits mode
STORE
HI or LO
b. Store numeric values, enter Limits mode
STORE
(numeric)
HI or LO
c. Toggle into/out of Limits mode while retaining values.
LIMITS
LIMITS
13
PEAK: toggle into/out of Peak mode. Previous peak values are lost each time the mode is reentered.
PEAK
PEAK

Figure 2-3. Programming Hierarchy (cont)

2-53. Measurement Terminals and Controls

2-54. GUARDING

2-55. General

2-56. Guarding may be used to reduce noise and improve accuracy. Common mode voltages, resulting from currents and voltage drops between two points otherwise electrically common, may cause significant errors. Proper use of a floating, guarded multimeter minimizes these errors.

2-57. Generally, guarding should be employed where long signal leads are used, when signal source impedance is high, when making measurements near high-level radiated noise (particularly at the power line frequency), or when making floating measurements.

NOTE

Errors due to thermal emf's should be considered when making low level, high resolution measurements. Thermal emf's (voltages produced by temperature differences between contacts of two dissimilar metals or by temperature gradients along a length of material) may cause differences of several microvolts. Since the multimeter utilizes copper input terminals, the use of low emf, shielded cables with copper spade lugs minimizes thermal emf errors.

2-58. Guard Selector and Guard Terminal

2-59. Correct use of the multimeter GUARD terminal both protects the instrument and provides more accurate readings. The Guard Selector (EXT GD IN), when disengaged (out), connects the internal guard. In many cases accurate measurements may be made with the selector in this position (shown as A in Figure 2-4). Here, the difference in potential between multimeter ground and device ground is very small, or the measurement is not critical. When pushed in, the selector disables the internal guard connection and allows for external guard connections as shown in B and C of Figure 2-4. The connection shown in B is better than that in A, since some common mode current (ICM) is shunted away from the source resistance. The connection shown in C is necessary when the source may not be capable of driving the guard. The buffer amplifier shown in C prevents this source loading. Practical considerations usually dictate which of the three connections is used.

2-60. Guard terminal connections are shown in Figure 2-4. Guard to chassis ground potential must not exceed 500V. Guard to SENSE LO potential must not exceed 127V.

2-61. VOLTS INPUT/OHMS SENSE (HI and LO) TERMINALS

2-62. Voltage and resistance measurements are made with the VOLTS INPUT/OHMS SENSE terminals, as

shown in Figure 2-5. The input on the HI terminal with respect to the LO terminal must not exceed 1000V. The LO to GUARD potential must not exceed 127V. These terminals are internally shorted to the AMPS INPUT/OHMS SOURCE terminals (HI to HI, LO to LO) when the Ohms Selector is in the disengaged (2-wire) position.

NOTE

In OHMS measurements, the voltage at the SENSE INPUT terminals is sampled before the Ohms Converter (Option 02) is connected. No connection is made if excessive voltage (±10V dc) is present.

2-63. AMPS INPUT/OHMS SOURCE (HI and LO) TERMINALS

2-64. The AMPS INPUT/OHMS SOURCE terminals are used when making current (A DC) or four-wire resistance (OHMS) measurements. The potential between SOURCE HI and SOURCE LO must not exceed 280V. The potential between SOURCE HI and SENSE HI, or between SOURCE LO and SENSE LO must not exceed 127V. When the Ohms Selector is in the disengaged (2T) position, these terminals are internally shorted to the VOLTS INPUT/OHMS SOURCE terminals (HI to HI, LO to LO).

NOTE

In A DC measurements, the voltage at the input terminals is sampled before the Current Shunts module (Option 03) is connected. No connection is made if excessive voltage (±45 V dc) is present.

2-65. OHMS SELECTOR

2-66. When engaged (in), the Ohms Selector control isolates SENSE HI from SOURCE HI and SENSE LO from SOURCE LO; four-wire resistance measurements can then be made. When disengaged (out), SENSE HI is connected to SOURCE HI and SENSE LO is connected to SOURCE LO for two-wire resistance measurements. The Ohms Selector does not influence the rear inputs (which are preset in a four-wire configuration). Refer to Figure 2-5. The Ohms Selector may remain disengaged (2T) for V DC or A DC measurements. However, for V AC measurements, it is recommended that the Ohms Selector be engaged (4T) in order to minimize input capacitance.

2-67. REAR INPUT SELECTOR

2-68. When pushed in, the Rear Input Selector disconnects all front panel inputs and connects the rear input connector. Rear inputs are identical to those on the front panel (with the addition of Ohms Guard). External reference inputs (HI and LO) are always applied through the rear connector (not switched). The Ohms Selector and Guard Selector have no effect when the rear inputs are enabled. The state of the Rear Input Selector can be determined remotely through any of the remote interface options.

2-69. Function

2-70. AC volts (HI ACCUR, NORMAL, or ENH'D), dc volts, and dc coupled ac volts are standard with the multimeter. Optional functions include resistance (OHMS) and dc current (A DC). Selection of a new function automatically cancels any previously selected function and places the multimeter in the function change configuration (refer to Table 2-2). If the same function is successively selected, the multimeter assumes the Autoranging mode, but retains all other modes and values existing prior to the reselection. One, two, or three annunciators light to verify a valid function selection. An invalid function selection occurs whenever the necessary analog measurement module is not installed or is faulty; either ERROR 9 or ERROR 3 appears in the display in such cases. Once an invalid function has been selected, the multimeter ignores all other push buttons until a valid function is selected.

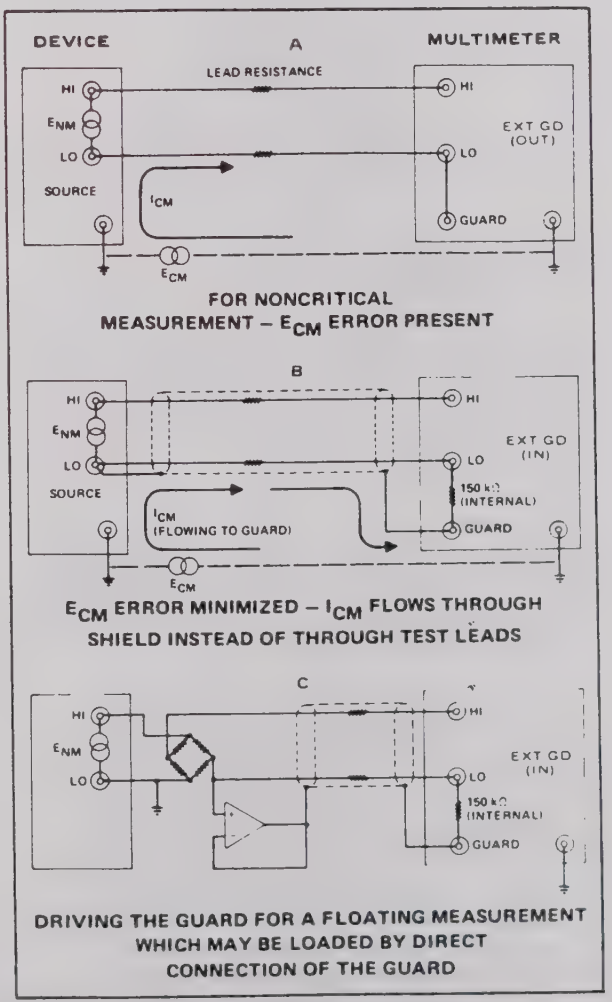


Figure 2-4. Guard Connections

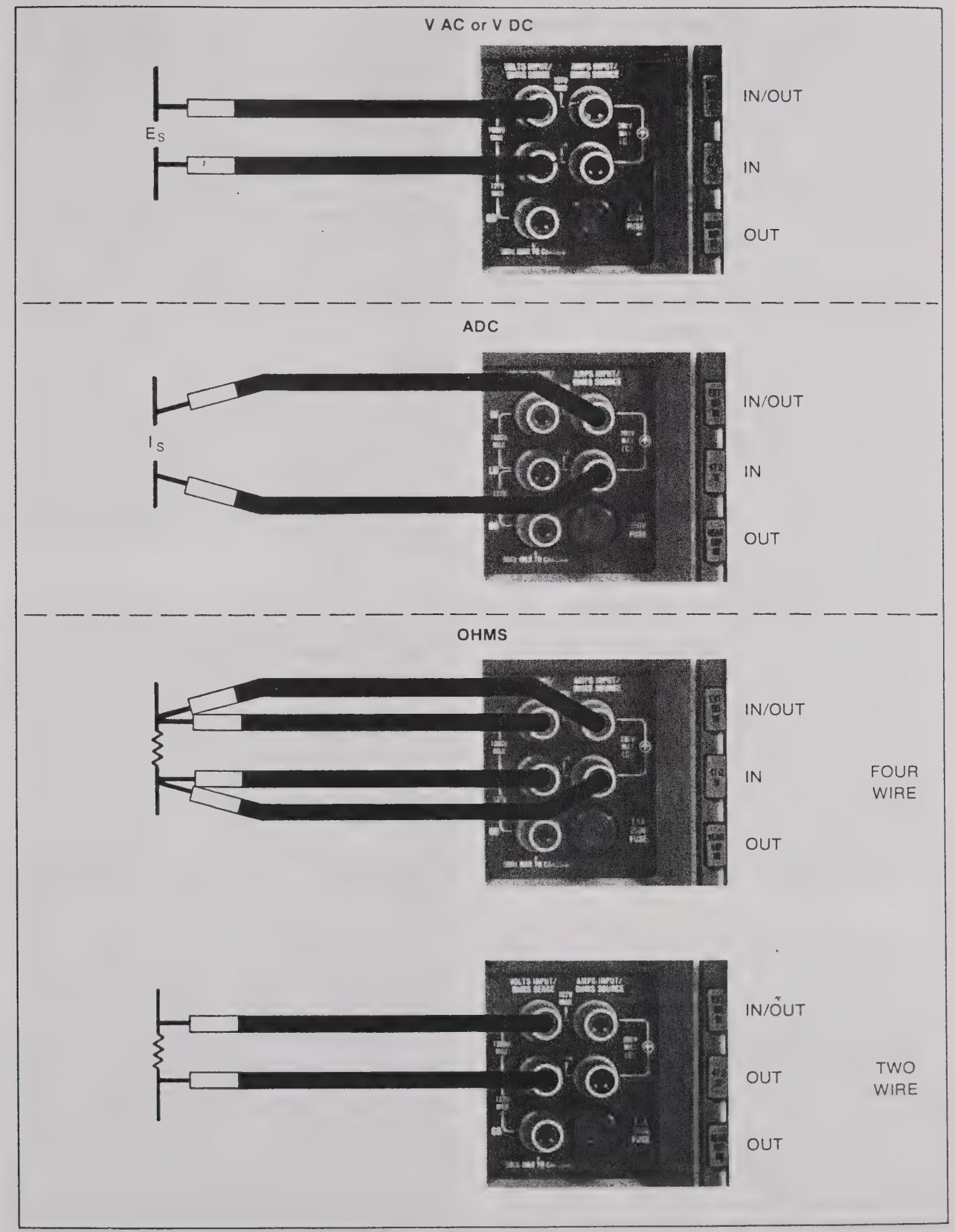


Figure 2-5. Measurement Connections

2-71. The Thermal True-RMS Converter uses three front panel function push buttons (V AC HI ACCUR, V AC NORMAL, and V AC ENH'D). The high accuracy mode (V AC HI ACCUR) requires approximately six seconds per reading, but the resulting accuracies of up to 0.016% rival those of thermal transfer standards (at a fraction of the time). The normal mode (V AC NORMAL) displays an rms value of the input (updated every 0.5 second), but with reduced accuracies since no sensor linearization is performed. The enhanced mode (V AC ENH'D) takes one initial high aocuracy measurement. This measurement is then used to correct subsequent measurements, which are made at normal mode speed (0.5 second). The enhanced mode is specified as long as the following conditions are maintained: the input cannot vary more than ±1% from that used for the initial high accuracy reading, the temperature cannot vary more than ±1°C, and the time lapse cannot exceed one hour. If the input changes by more than ±1% from that used in the initial high accuracy reading, another high accuracy reading is taken to automatically update the correction factor.

2-72. Measurement Parameters

2-73. SAMPLING

2-74. AC Volts Functions

2-75. One sample is taken for each V AC reading. Reading time in NORMAL is approximately 0.5 second. HI ACCUR readings require six seconds. ENH'D requires an initial six second high accuracy reading, then reverts to 0.5 second normal readings. Any of these reading times may be lengthened slightly when mathematic operations are in effect. The SAMPLE push button is inoperative when the multimeter is set for ac volts measurements (pushing SAMPLE causes an Error A). A new high accuracy measurement can be commanded in the enhanced mode (ENH'D) by pushing the ENH'D button again. Similarly, when the dc coupled enhanced mode is used, a new high accuracy measurement can be commanded by simultaneously pushing the ENH'D and V DC buttons.

NOTE

In the Enhanced mode, the Thermal True-RMS Converter automatically takes a new reading to establish a new correction factor if the range changes (either manual or autorange), the filter setting changes, or the difference between the reading and the present correction factor is ≈1%.

2-76. DC Volts, Resistance, and DC Current Functions

2-77. The multimeter averages a selectable number of samples for each reading (display update) in V DC, OHMS, or A DC. Noise rejection is influenced by the number of samples-per-reading and by the filter selection. Each sample-per-reading setting yields a specific processing time. Additional processing time is necessary when mathematic operations (such as OFFSET or SCALING) are involved. Samples taken are synchronous to the line frequency for local (front panel) operation. Synchronous or asynchronous operation may be specified remotely.

2-78. Sample settings are specified as exponents of two. For example, the SAMPLE push button can be used individually to toggle between settings 5 (2 exponent 5 = 32 samples-per-reading) and 7 (2 exponent 7 = 128 samples-per-reading). Further, any sample setting (exponent of 2) from 0 through 17 may be made using the STORE (numeric) SAMPLE sequence. If a setting of 0 through 6 is in effect when SAMPLE is toggled, the multimeter assumes setting 7. A previous setting of 7 through 17 is changed to setting 5 when SAMPLE is toggled.

2-79. The SAMPLE annunciator is controlled by both the sample setting and the trigger. At sample settings from 0 through 7, SAMPLE flashes once for each triggered reading. The rapid reading rate at 0 or 1 setting yields an apparent steady indication. At sample settings 8 through 17, the flash rate is preset to that of setting 7. This feature insures a reliable reading-in-progress indication at these slower reading rates.

2-80. TRIGGERING

2-81. Each new measurement is initiated with a trigger. In AUTO triggering, the trigger is generated internally at the end of the required reading time. Triggers may also be applied locally (from the front panel) or remotely.

2-82. Auto trigger commands a continuously updated reading. The frequency of this updating is influenced by the number of samples-per-reading and by any extra processing time required by mathematic operations. The SAMPLE annunciator flashes to indicate the triggering of a new reading.

2-83. Local triggers can be manually commanded from the front panel. The duration of each reading is determined in the same manner as the auto triggers (samples, mathematics). Each use of the MANUAL/EXTERNAL push button commands an immediate response from the multimeter; any reading already in progress is aborted and a new reading begun. During any manually triggered reading, use of any other push button halts the multimeter; a new trigger must then be entered. Conversely, between manually triggered readings, the multimeter is inhibited; no display update or SAMPLE annunciation is evident. During this interval, any measurement parameter, mathematic operation, or special operation may be entered, but is not initiated until the next manual trigger is entered.

2-84. External triggers are applied through the rear panel TRIGGER jack. A local trigger manually applied from the front panel overrides a simultaneously applied external trigger.

2-85. FILTERING

2-86. AC Volts Functions

2-87. Two filter modes (off and on) are available when the multimeter is set for ac volts measurements (HI ACCUR, NORMAL, or ENH'D). The filter off mode (F0) is set when changing into a V AC function from V DC, A DC, or OHMS. Most V AC measurements use the filter off mode. The filter on mode (F) is to be used only when the input signal frequency is below 40 Hz. Degraded accuracies result if filter on mode is used at higher signal frequencies. The filter mode can be changed by toggling the FILTER button (FILTER annunciator is on for filter on mode and off for filter off mode). When any V AC function is selected while a V AC function is already in effect, no filter mode change is made.

2-88. DC Volts, Resistance, DC Current Functions

2-89. Five filter modes are available. Either of two analog filters (or filter bypass) may be selected. The slow filter provides better normal mode rejection. The fast filter allows for faster instrument settling while still providing a degree of noise rejection. Whenever a filter is used, a timeout (for settling delay) may also be inserted before each reading. No filtering is available for the external reference inputs. Table 2-6 defines the five filter modes.

2-90. Two methods of filter selection are available in V DC, A DC, or OHMS. Selection of any mode (F,F0,F1, F2, F3) is possible using the STORE (numeric) FILTER sequence. The FILTER push button by itself toggles between modes F (slow, no timeout, annunciator on) and F0 (fast, no timeout, annunciator off). The multimeter uses a preset selection pattern if a mode other than F or F0 is already selected when FILTER is toggled. The slow filter (F) is always selected when a toggle is performed with a fast filter (F0, F1, or F3) in effect. The fast filter (F0) is always selected when a slow filter (F or F2) is in effect. Mode F0 is preselected at power-up or reset. RECALL FILTER may be used at any time to verify the filter combination in use (without changing the filter mode).

2-91. AVERAGING

2-92. The Averaging mode presets the sample setting to 10 (2 exponent 10 = 1024 samples-per-reading) and the filter mode to F (slow filter, no time out). These settings provide optimum stability and resolution throughout the range of inputs. Subsequent use of the SAMPLE or FILTER push button while in Averaging mode may jeopardize this intended optimization. Therefore, sample settings less than 10 cause the multimeter to exit the Averaging mode. For example, a sample setting of 12, which specifies greater noise rejection than the setting of 10, is accepted and retained for all ranges within the same function. Conversely, a sample setting of 7, offering less stability, is accepted (but causes the multimeter to exit the Averaging mode).

Table 2-6. Filter Modes (V DC, A DC, OHMS)

MODE NUMBER	FILTER	TIMEOUT	FILTER LED
(blank)	slow	none	on
0	fast	none	off
1	bypass	none	off
2	slow	550 ms	on
3	fast	50 ms	off
(No Mode Number is used for slow filter without timeout. Push STORE FILTER.)			

2-93. Filter mode F2 can also be selected in Averaging mode. Any filter selected other than F or F2 is accepted by the multimeter, but causes deactivation of Averaging mode.

2-94. The Average mode can be used to improve display stability (reduce rattle) for measurements in V DC, OHMS, or A DC. Averaging mode is not available in any of the ac volts functions (although the AVG pushbutton can be used to command extended resolution in V AC functions). In V DC, OHMS, and A DC functions, the Average mode provides increased display stability in all ranges and an increase in display resolution in certain ranges. In V DC (10V range only), a total of 7-1/2 digits is now available. Other V DC ranges still provide 6-1/2 digits of resolution. In A DC, 6-1/2 digits (instead of the standard 5-1/2) are now available in all ranges. In OHMS, a total of 6-1/2 digits is available on all ranges. Preset resolutions used for standard operation and for the Average mode are summarized in Table 2-7.

NOTE

When the Average mode is enabled in the 10V dc range, the exponent field displays the seventh mantissa digit and does not indicate the reading's exponent. In this case the reading's decade multiplier cannot be interpreted from the display if a math function (such as offset or scaling) is enabled.

2-95. RANGE

2-96. Ranges available in each function are summarized in Table 2-3. A power-up or reset condition sets the multimeter in the 1000V range (V DC function), Autoranging disabled. Any function selection enables Autoranging (AUTO annunciator on). Autoranging begins on the highest range for each function (1000V dc, 500V ac, 100 Megohm, or 1A). In V AC only, autoranging begins at the previous range when selecting between V AC functions. In Autoranging, the multimeter selects the range offering maximum resolution for the measured value. The AUTO (range) push button toggles Autoranging mode on or off. When toggling off, no range change is effected. Either of the up/down push buttons select manual ranging and step up/down one range when initially used. Each subsequent use steps to the next

higher/lower range (if available). A range identifier is also displayed with each range change in V AC functions. This identifier may also be used at any time in VAC to verify the range in use: just reselect the V AC function being used.

2-97. AC volts can be measured on the following eight ranges: 100 mV, 300 mV, 1V, 3V, 10V, 30V, 100V, and 500V. Resolutions vary respectively from 1 uV to 1 mV in standard operation (or from 1 uV to 100 uV when the AVG button has been used to command extended resolution). Input impedance is 1 megohm/<180 pF. Resolution in each range is illustrated in Table 2-3.

2-98. DC volts can be measured on five successive ranges from 100 mV to 1000V. Respective resolutions vary from 100 nV to 1 mV. Refer to Table 2-3 for a presentation of display resolution in each range. Input impedance on the 100V and 1000V ranges is 10 Megohms. On the lower three ranges it is greater than 10,000 Megohms.

2-99. Out of range indications are displayed whenever the reading does not fall within the specified rating in a particular range. When the multimeter is in autoranging, autoranging points cause an automatic new range selection, averting an out of range indication. An out of range indication cannot be averted if the reading is less than that allowed in the lowest range (LLLLLL displayed in V AC functions only) or greater than that allowed in the highest range (HHHHHH displayed in all functions). When the multimeter is in manual ranging, an out of range indication can be disabled by manually selecting a higher or lower range. Out of range values are presented in Table 2-4.

Table 2-7. Resolution

	RANGE	STANDARD DIGITS	AVERAGING DIGITS
V DC	100 mV	6½	6½
	1V	6½	6½
	10V	6½	7½
	100V	6½	6½
	1000V	6½	6½
OHMS	10Ω	5½	6½
	100Ω	5½	6½
	1 kΩ	6½	6½
	10 kΩ	6½	6½
	100 kΩ	6½	6½
	1 MΩ	5½	6½
	10 MΩ	5½	6½
	100 MΩ	5½	6½
A DC	100 μA	5½	6½
	1 mA	5½	6½
	10 mA	5½	6½
	100 mA	5½	6½
	1A	5½	6½

2-100. V DC AND OHMS ZERO

2-101. During normal operation (Calibration mode OFF), the ZERO push button is used to store and apply temporary zero correction factors for the V DC and OHMS functions. These "temporary zeros" correct for drifts in dc offsets that may have occurred since the last calibration. The temporary zeros may also be used to correct for offsets in the external test system, such as in the test leads or in an external scanner. The temporary zeros supplement non-volatile ("permanent") zeros which are stored during calibration.

2-101a. Pressing the ZERO push button toggles Zero mode on and off. While Zero mode is on (ZERO annunciator lit), the multimeter applies both the permanent and the temporary zeros to V DC and OHMS readings. While Zero mode is off (ZERO annunciator off), the multimeter applies only the permanent zeros. Attempting to toggle Zero mode on in the A DC or V AC functions causes the multimeter to indicate Error 0.

2-101b. Every time Zero mode is toggled on (ZERO annunciator lit), the multimeter stores a new temporary zero for the range that is presently selected. The multimeter automatically stores the same zero for all higher ranges in the same function. A separate zero may be stored for each range. (Start with the lower ranges so that later zeros do not overwrite previous zeros.) The temporary zeros are all set to 0 when the multimeter is reset or powered up.

2-101c. Exiting the zeroed function deactivates Zero mode, but retains the stored zero values. Reselecting the zeroed function automatically reactivates Zero mode and restores the old zero values.

2-101d. Whenever a zero is stored (i.e, whenever Zero mode is toggled on), the INPUT HI and INPUT LO terminals must be shorted together. (If storing a zero in the OHMS function, select the two-wire configuration or also short SENSE HI and SENSE LO.) To zero the multimeter's internal offsets, short the inputs with a high-quality, low-thermal shorting bar. To also zero the offsets in the external test system, short the inputs with the test leads instead.

2-101e. The RECALL push button can be used to recall the zero correction factors. For an explanation of the use of the ZERO push button during calibration, refer to Appendix 7B.

2-102. Mathematic Operations

2-103. Mathematic operations can be specified to change the measured value (as influenced by measurement parameters) before it is actually displayed. Ratio, deviation, percentage variation and other mathematically manipulated displays are thereby possible. Scaling can be used to divide the measured value and display the ratio. An offset value can be subtracted

from the measured value to display only the deviation. Scaling and Offset can be used in combination to display percentage variation. Examples of such operations are given in Applications later in this section.

2-104. Use of mathematic operations is expressed in the following formula:

$$\text{DISPLAY} = \frac{\text{MEASURED VALUE}}{\text{SCALING (OR EXTERNAL REFERENCE)}} - \text{OFFSET}$$

Measured value in this formula refers to the measurement as influenced by all selected measurement parameters. This value is subject to the following function-dependent considerations.

1. VDC or OHMS functions: any applied zero value is first subtracted, yielding the measured value.

2. VAC functions: External Reference cannot be used.

2-105. SCALING

NOTE

If the multimeter is in both Scaling and Offset modes, the scaling value is applied before the offset value.

2-106. The Scaling mode divides the measured value (after application of V DC or OHMS zero) by a known amount and displays the quotient. Ratios, percentage deviations, or input/output relationships can thereby be displayed. The scaling divisor may be a previously displayed and stored value, or any non-zero numeric entry from $+10^9$ to $+10^{-9}$ and from -10^9 to -10^{-9}. When compared to External Reference, Scaling offers a much wider range. Only one scaling factor may be stored at a time.

2-107. Storing the displayed value as a scaling factor warrants a word of caution: ensure that the displayed value is the true original display by first toggling out of Scaling and Offset modes (respective annunciators off). No stored scaling or offset value is lost in this manner. To store the desired display, push STORE SCALING.

2-108. EXTERNAL REFERENCE

NOTE

External Reference mode is not available in ac voltage functions (NORMAL, ENH'D, or HI ACCUR). Attempting to enter External Reference mode in any V AC function causes an Error A condition.

2-109. Scaling and External Reference modes are mutually exclusive: selection of either mode automatically disables the other. The External Reference value (always measured as a dc voltage) is applied as an unswitched input through the rear input connector.

2-110. Immediately after a power-up or reset, RECALL EXT REF can be used to verify the multimeter's software number. The first subsequent use of EXT REF to activate External Reference mode disables this software identification feature. When enabling External Reference mode, the reference voltage is displayed as long as the EXT REF button is depressed. The EXT annunciator is lighted when the mode is enabled.

2-111. The external reference voltage may be a maximum of ±20V dc on either high or low External Reference input with respect to VOLTS INPUT LO. The voltage between External Reference high and low may not exceed 40V dc. The minimum acceptable External Reference voltage is the greater of ±100 uV or a value found with the following formula:

$$V_{min} = \frac{\pm \text{ Vin}}{10^9}$$

2-112. Usually, the External Reference low terminal is externally tied to VOLTS INPUT LO. In any event, the resistance between either External Reference terminal and VOLTS INPUT LO should be less than 20 kilohms. A reading rate of eight samples-per-reading and filter bypass are specified for the External Reference input.

2-113. OFFSET

2-114. In Offset mode, the display represents the deviation from a stored offset value. Measurements of stability or analog variation are thereby possible. The multimeter automatically subtracts a programmed numeric (or previously stored display value) from the measurement and displays the result. No increase in resolution is displayed while in the Offset mode. One value (whether a numeric or a previous display) may be stored at a time. Programmed numerics may range from $+10^9$ to -10^9. The stored offset value may be recalled at any time.

2-115. Special Operations

2-116. PEAK

2-117. The highest and lowest deviations in the displayed value may be recorded in the Peak mode. Source stability may thereby be checked over a period of time. The PEAK push button toggles into/out of the Peak mode. High and low Peak values may be recalled at any time without exiting the Peak mode or interrupting further peak recording. The following sequence is used:

RECALL HI PEAK

RECALL LO PEAK

The high or low peak value is latched in the display as long as the PEAK button is held depressed.

2-118. Exiting the Peak mode (toggle PEAK once) halts further peak recording, but does not erase previously

recorded high and low values. A multimeter function change disables Peak mode and retains peak values. At any time, reentry into the Peak mode (toggle PEAK again) erases previously recorded values. Both Peak mode and peak values are lost during a Power-Up or Reset condition.

2-119. LIMITS

2-120. The Limits mode may be employed to display a pass-fail indication of measurement values. The mode is entered when a single high or low limit value is stored, or when the LIMITS button is pushed. A second store sequence must be used if both high and low limits are desired. Either the regularly displayed value or programmed numerics may be used for the limit values. For example, high and low limits of 12.05 and 11.95 would be programmed as follows:

STORE 1 2 . 0 5 HI

STORE 1 1 . 9 5 LO

In this example, the multimeter enters the Limits mode when either the HI or LO button is first pushed. Mode entry is verified by a display of HI, LO, or PASS. In this case, readings higher than 12.05 yield a HI display, readings lower than 11.95 yield LO, and all other readings yield PASS. The limit value(s) are compared to the now transparent display reading with all other parameters and operations still in effect.

2-121. A display reading can also be stored as a limit value. Use the following sequence:

STORE HI (or LO)

2-122. Use of Limits mode does not interrupt other uses of the multimeter. No measurement parameter or mathematic operation is changed: The other special operation (Peak) may be used simultaneously with Limits mode. Any of the measurement parameters or operations may be enabled, changed, or recalled while in the Limits mode: the display responds in the standard fashion during this process and automatically reverts to limits indications once the process is complete. Limits values may be recalled at any time (Limits mode enabled or disabled). The recall sequence does not change the state of the Limits mode. The following recall sequence is used:

RECALL HI LIMITS

RECALL LO LIMITS

The recalled value is latched in the display as long as the LIMITS button is held depressed.

2-123. Pushing the LIMITS button toggles the multimeter into or out of the Limits mode whether or not limits values have been entered. A function change disables the Limits mode, but retains any existing limit values. Once stored, limits values are retained during all but Power-Up and Reset sequences.

2-124. Remote Control

2-125. The multimeter may be equipped with any of three remote interface modules. These modules are fully explained in Section 6. When the IEEE Remote Interface (Option 05) is installed, the front panel LCL/RMT push button can be used to enable local control, but cannot be used to enable remote control. Remote control can only be commanded from the remote location with this interface.

2-126. The LCL/RMT push button may be used to toggle into/out of remote control when either the Bit Serial Remote Interface (Option 06) or the Parallel Remote Interface (Option 07) is installed. Whenever the multimeter is in remote control, whether commanded locally or from the remote, the REMOTE annunciator is lighted.

2-127. When in remote, only the POWER push button remains operational in all circumstances. The LCL/RMT push button may remain operational, but is disabled by a local lockout or display off command from the remote (refer to Section 6). A power interruption, whether caused by line failure or toggling of the power push button, returns the multimeter to local control.

2-128. Calibration Mode

2-129. DESCRIPTION

2-130. The rear panel calibration switch is used to enable or disable the Calibration mode (remove calibration seal for access). The AVG/(CAL) annunciator flashes when the Calibration mode is enabled, or is lit steadily when the Averaging mode is enabled. Regular multimeter operation is significantly altered while in the Calibration mode:

1. Power must not be cycled on or off when the Calibration mode is activated (rear panel Calibration Switch on).

2. Overrange conditions no longer cause a special flashing "HHHHHH" indication.

3. Underrange conditions in V AC functions no longer cause a "flashing L" indication.

4. Averaging mode is locked out: the Calibration and Averaging modes are mutually exclusive. However, pushing the AVG button when Calibration mode is on does enable or disable latching error indications.

5. All mathematic operations and special operations are disabled.

6. 7-1/2 digits are displayed on 10V dc range and 6-1/2 digits are displayed on all other functions and ranges. A sign (±) is displayed for all functions to facilitate potentiometer adjustment.

7. Calibration correction factors (for each range in V DC, A DC, OHMS, and for VAC ranges at a

frequency of interest) and the calibration date may be stored.

2-131. Hardware calibration is facilitated while in Calibration mode. Enhanced resolution allows for more precise potentiometer adjustment during hardware calibration. With no mathematic operations allowed, the display represents the true input value.

2-132. Troubleshooting is also aided by using the Calibration mode. Latching errors can be disabled to allow special module configurations.

CAUTION

Latching errors are intended for multimeter protection and must not be disabled during normal operation or calibration. Refer to Troubleshooting in Section 4.

2-133. USE

2-134. The multimeter uses three calibration controls: the rear panel calibration switch, and the front panel (CAL DATE) and (CAL COR) push buttons. The rear panel calibration switch activates the Calibration mode and enables use of the (CAL COR) and (CAL DATE) push buttons. Store operations with these two push buttons are used for software calibration and are explained in Appendix 7B. Recall operations can be performed at any time and are explained in the following paragraphs.

2-135. The (CAL DATE) push button can be used in all functions (including the three V AC functions) to recall a six digit number. This number may signify the calibration date. For example, a recalled 0 2 1 8 8 3 would signify February 18, 1983. Alternately, the six digits may be used to identify the multimeter.

2-136. To recall the six digit date (or identifier) while in the Calibration mode, push:

RECALL (CAL DATE)

If the multimeter is not in the Calibration mode, the six digit date (or identifier) may be recalled using the following sequence:

RECALL LO (CAL DATE)

2-137. The (CAL COR) push button may be used to recall the uncorrected reading when the multimeter is in the Calibration mode, use:

RECALL (CAL COR)

The uncorrected reading can also be recalled when the multimeter is not in the Calibration mode. Use the following sequence:

RECALL LO (CAL COR)

2-138. Scan Advance

2-139. The multimeter outputs a sync signal during each measurement sequence. This signal occurs after the measurement is complete, but before a new trigger is accepted. The sync signal thereby allows for faster bus communications by advancing a scanner before a new reading is triggered. The signal (positive going TTL, 3 microsecond pulse width, 50-ohm output impedance) is available at a BNC connector on the multimeter rear panel.

2-140. Systems Use

2-141. The availability of optional interface modules makes the multimeter adaptable to a large variety of digital systems. Operating and programming instructions related to remote operation are included with the appropriate optional module.

2-142. OPERATION

2-143. Initial Turn-On

2-144. Before initial turn-on, check that the line voltage specified on the rear panel sticker (near the line fuse) agrees with the line voltage actually being used. If there is any doubt concerning the line voltage setting, refer to Line Voltage Selection in Section 4. Also verify that the Calibration Switch is off. Once these verifications have been made, connect the power cord and push the POWER button to ON.

2-145. The multimeter identifies its own software and hardware at initial turn-on. Software is identified with a display of "HI - Y.Y.Y", where "Y" represents the software version in use. Hardware is then identified with a display of "CXXXXX," where "X" signifies any installed options by number (or the Thermal True-RMS Converter as A).

2-146. The power-up (reset) configuration is now established. The multimeter is set for the V DC function, the 1000V manual range, filter mode F0, sample factor 7, auto trigger, zero mode on, and local operation. All other modes and values are disabled, The multimeter may now be programmed as described in this Section. A two-hour warm-up ensures rated accuracy. Better accuracies can be obtained in the Averaging mode (after a four-hour warm-up).

2-147. Initial Set-Up

2-148. The three front panel terminal controls (Rear Input Selector, Ohms Selector, and Guard Selector) must be positioned correctly prior to taking measurements. Use the following guidelines:

1. The Rear Input Selector must be disengaged (out) for front panel inputs or engaged (in) for inputs applied through the rear panel connector. Ohms Guard is only available through the rear connection. External Reference HI and LO is always available through the rear input connector (not switched).

2. The Ohms Selector must be disengaged (out) for two-wire resistance measurements or engaged (in) for four-wire resistance measurements. For all other functions, the Ohms Selector can be left disengaged. However, it is recommended that the Ohms Selector be engaged (in) whenever making

V AC measurements. This setting minimizes input capacitance.

NOTE

The Ohms Selector has no affect on rear inputs. Rear inputs are dedicated in a four-wire configuration.

3. The Guard Selector is disengaged (out) for non-critical measurements. Refer to Measurement Terminals and Controls for a full description of guarding when this selector is engaged (in). The Guard Selector has no affect on the rear inputs.

2-149. Measurement parameters, mathematic operations, and special operations can be specified prior to or during measurements. These parameters and operations can be applied to measurements in any function, with the following exceptions:

1. External Reference mode is not available in any of the V AC functions (HI ACCUR, NORMAL, or ENH'D).

2. Averaging is not available in any of the V AC functions (HI ACCUR, NORMAL, or ENH'D). The AVG pushbutton may be used in the V AC functions to enable an extended display resolution.

2-150. Front panel programming of the multimeter is best accomplished in a sequential manner. This sequence is fully explained in Figure 2-3. Often, only measurement parameters need be specified. Programming of any mathematic operation requires consideration of mathematics already in effect.

2-151. Refer to Figure 2-5 for an outline of measurement connections. Also refer to Measurement Terminals and Controls earlier in this Section.

2-152. Measurement Instructions

2-153. AC VOLTS (THERMAL TRUE-RMS)

NOTE

It is recommended that all ac volts measurements be made with the the Ohms Selector in the engaged (in) position to minimize input capacitance.

2-154. Thermal ac-ac transfer measurements can be made using the Thermal True-RMS Converter Module. Select the mode of operation desired, as determined by the degree of accuracy and speed required.

2-155. AC Volts Normal Mode (V AC NORMAL)

2-156. Use the following procedure when measuring ac volts with the normal mode of the Thermal True-RMS Converter:

1. Push the V AC NORMAL button (NORMAL annunciator lights).

2. The multimeter assumes autoranging (beginning at the 500V range) when a V AC function is selected. However, if a V AC function was previously in effect, the previous range is retained as the starting point for any possible autoranging.

3. Select the filter by pushing the FILTER button if the frequency of the input signal is ≤40 Hz. (The accuracy of the instrument is degraded if the filter is selected for higher input frequencies).

4. Connect the ac voltage to the HI and LO SENSE INPUT terminals).

2-157. AC Volts Enhanced Mode (V AC ENH'D)

2-158. Use the following procedure when measuring ac volts with the enhanced mode of the Thermal True-RMS Converter:

1. Push the V AC ENH'D button (ENH'D annunciators light).

2. The multimeter assumes autoranging (beginning at the 500V range) when a V AC function is selected. However, if a V AC function was previously in effect, the previous range is retained as the starting point for any possible autoranging.

3. Select the filter by pushing the FILTER button if the frequency of the input signal is ≤40 Hz. (The accuracy of the instrument is degraded if the filter is selected for higher input frequencies).

4. Connect the unknown ac voltage to the HI and LO SENSE INPUT terminals.

5. The initial high accuracy measurement requires six seconds. The rms voltage should be displayed within 0.5 second of the completion of this initial high accuracy reading and updated every 0.5 second thereafter.

6. A new high accuracy measurement can be commanded at any time by pushing the ENH'D button again. After six seconds, the SAMPLE annunciator flashes briefly and 0.5 second updates resume.

NOTE

The Thermal True-RMS Converter automatically takes a new reading to establish a new correction factor if the range changes (either manual or autorange), the filter setting changes, or the difference between the reading and the present correction factor is ≥1%.

2-159. AC Volts High Accuracy Mode

2-160. Use the following procedure when measuring ac volts with the high accuracy mode of the Thermal True-RMS Converter:

1. Push the V AC HI ACCUR button (HI ACCUR annunciator lights).

2. The multimeter assumes autoranging (beginning at the 500V range) when a V AC function is selected. However, if a V AC function was previously in effect, the previous range is retained as the starting point for any possible autoranging.

3. Select the filter by pushing the FILTER button if the frequency of the input signal is ≤40 Hz. (The accuracy of the instrument is degraded if the filter is selected for higher input frequencies).

4. Connect the unknown voltage to HI and LO SENSE INPUT terminals.

5. The multimeter requires approximately six seconds for each high accuracy measurement.

2-161. AC VOLTS - DC COUPLED (THERMAL TRUE-RMS)

2-162. AC Volts Normal Mode on DC Volts

2-163. Use the following procedure when measuring ac volts (dc coupled) with the normal mode of the Thermal True-RMS Converter:

1. Simulaneously push the V AC NORMAL and V DC buttons (NORMAL and V DC annunciators light).

2. The multimeter assumes autoranging (beginning at the 500V range) when a V AC function is selected. However, if a V AC function was previously in effect, the previous range is retained as the starting point for any possible autoranging.

3. Select the filter by pushing the FILTER button if the frequency of the input signal is ≤40 Hz. (The accuracy of the instrument is degraded if the filter is selected for higher input frequencies).

4. Connect the unknown voltage to the HI and LO SENSE INPUT terminals.

5. The ac voltage display is updated every 0.5 second.

2-164. AC Volts Enhanced Mode (DC Coupled)

2-165. Use the following procedure when measuring ac volts (dc coupled) with the enhanced mode:

1. Simultaneously push the V AC ENH'D and V DC buttons (ENH'D and V DC annunciators light).

2. The multimeter assumes autoranging (beginning at the 500V range) when a V AC function is selected. However, if a V AC function was previously in effect, the previous range is retained as the starting point for any possible autoranging.

3. Select the filter by pushing the FILTER button if the frequency of the input signal is ≤40 Hz. (The accuracy of the instrument is degraded if the filter is selected for higher input frequencies).

4. Connect the unknown voltage to the HI and LO SENSE INPUT terminals.

5. The multimeter requires approximately six seconds for the initial high accuracy measurement. The ac voltage should be displayed within 0.5 second after completion of the initial measurement and updated every 0.5 second thereafter.

6. A new high accuracy measurement can be commanded at any time by pushing the ENH'D button again. After six seconds, the SAMPLE annunciator flashes briefly and 0.5 second updates resume.

NOTE

The Thermal True-RMS Converter automatically takes a new reading to establish a new correction factor if the range changes (either manual or autorange), the filter setting changes, or the difference between the reading and the present correction factor is ≥1%.

2-166. AC Volts High Accuracy Mode (DC Coupled)

2-167. Use the following procedure when measuring ac volts high accuracy (dc coupled) using the Thermal True-RMS Converter:

1. Simultaneously push the V AC HI ACCUR and V DC buttons (HI ACCUR and V DC annunciators light).

2. The multimeter assumes autoranging (beginning at the 500V range) when a V AC function is selected. However, if a V AC function was previously in effect, the previous range is retained as the starting point for any possible autoranging.

3. Select the filter by pushing the FILTER button if the frequency of the input signal is ≤40 Hz. (The accuracy of the instrument is degraded if the filter is selected for higher input frequencies).

4. Connect the unknown voltage to HI and LO SENSE INPUT terminals.

5. The multimeter requires approximately six seconds for each accuracy measurement.

2-168. DC VOLTAGE (V DC)

2-169. Use the following procedures when making dc voltage measurements from the front panel:

1. Push the V DC button (V DC annunciator lights).

2. The multimeter assumes the autoranging mode at the highest (1000V dc) range. Manual range selection may also be made. Available ranges are: 1000V, 100V, 10V, 1V, and 100 mV.

3. Set or revise the required measurement parameters, mathematic operations, and special operations (refer to Figure 2-3).

4. Apply the unknown voltage to the HI and LO SENSE INPUT terminals.

2-170. APPLICATIONS

2-171. Specific applications using the multimeter are presented in Table 2-8. If these examples are duplicated on the multimeter, a power-up or reset configuration is first required.

Table 2-8. Applications

APPLICATION 1 (V AC)	
REQUIREMENT:	Characterize on AC Standard (Fluke 5200A) using the multimeter and a known ac source.
METHOD:	Connect the multimeter (set for V AC HI ACCUR) to a known value ac source (such as a characterized Fluke 5200A). Record the reading. Now connect the multimeter to another 5200A (the one being characterized). Adjust this second 5200A for a High Accuracy reading equal to that originally recorded.
APPLICATION 2 (V AC)	
REQUIREMENT:	Monitor the stability of an ac source in terms of its deviation in volts from a present output of 10V ac.
METHOD:	Store the present output as an offset. Push: STORE OFFSET Offset mode is now enabled. The multimeter will read only the deviation from the original 10V ac reading.
APPLICATION 3 (V DC)	
REQUIREMENT:	Determine which of a group of power supplies has a tolerance of 15V ±100 mV.
METHOD:	Set high and low limits. Press: STORE — 1 — 5 — • — 1 — HI STORE — 1 — 4 — • — 9 — LO The multimeter will now display "HI," "LO," or "PASS" for each power supply.

Table 2-8. Applications (cont)

APPLICATION 4 (V DC)	
REQUIREMENT:	Monitor the stability of a power supply as a decimal ratio to its present reading of -20.08V. DC zeroing appears to be necessary.
METHOD:	Perform V DC Zeroing for internal drift. Apply low thermal short between INPUT HI and LO (at the terminals). Press: ZERO VDC/Ω The value stored will be displayed as long as VDC/Ω ZERO is held depressed. Release of the switch will activate the Zero mode. Revise terminal interconnections for dc volts measurements. Connect the dc voltage. Apply power supply reading of -20.08V as a scaling factor. Press: STORE — SCALING Display will now yield the ratio of subsequent readings to the scaling factor, e.g., an input of 22.08V yields a ratio of: $\frac{22.088}{20.08} = 1:1$

APPLICATION 5 (V DC)	
REQUIREMENT:	Display the input error voltage for an operational amplifier by measuring the dc output error. Gain = 2.6847×10^4.
METHOD:	Divide the measured dc output error by a scaling factor (the op amp gain). Press: STORE — 2 — . — 6 — 8 — 4 7 — EXP — 4 — SCALING The multimeter will now divide the measured input by the gain of the op amp and display the input error voltage.

Section 2A
Remote Programming Commands

2A-1. INTRODUCTION

2A-2. This section documents remote operation of the multimeter with any of the following interface modules installed:

1. IEEE-488 Interface (Option -05)
2. Bit Serial Interface (Option -06)
3. Parallel Interface (Option -07)

2A-3. Basic remote operation for 8500 series multimeters is detailed in Table 2A-1. These operating features are generally compatible with the 8505A and 8506A multimeters. Table 2A-2 details additional remote operating features available with the 8505A and 8506A only.

2A-4. General information, theory of operation, maintenance information, parts lists, and schematic diagrams for each of the three remote interfaces are presented in Section 6 of this manual.

2A-5. Software calibration for each function can be accomplished locally or remotely. Complete software calibration information is presented in Section 7 of this manual.

Table 2A-1. Programming Instructions

The programming instructions in this table pertain to the 8500 Series Digital Multimeters with the IEEE-488 Interface (Option -05), the Bit Serial Interface (Option -06) or the Parallel Interface (Option -07) installed. Features and instructions unique to the DMM model or to the Interface used will be identified in the following manner:

1. 8500A or 8502A: the symbol ◆ will denote an explanation applicable to one DMM model only. The software version incorporated in the DMM may also be mentioned for further identification. To verify the software version incorporated in your instrument, observe the display indication at power on or reset. For example, in the 8502A, "HI-2.0.2" will appear in the display for models with software version 2.0.2.

2. -05, -06, or -07 Interface Options: the symbol ● will be used with a feature or instruction unique to a particular Interface.

INITIALIZATION

When power is applied, or the Reset character (*) is transmitted, the instrument assumes a preset default condition. This condition is defined by the following remote codes:

	REMOTE CODE	COMMAND
	V	Volts DC
	R4	1000V range
◆	S5 (8500A)	2^5 Samples per Reading
◆	S7 (8502A)	2^7 Samples per Reading
	F0	Fast Filter, Timeout Disabled (Panel Indicator OFF)
	X0	External Reference/Scaling Disabled
	P0	Offset Feature Disabled
	U0	Limits-Peak Value Storage Disabled
	T0	Single Reading Line Synchronous
	B0	Single Character ASCII Format
	D0	Front Panel Display Active
	L0	Deactivate Local Lockout
	J0	Deactivate Line Feed Suppression
	M0	Enable Cal Memory Factors
◆	Q0 (8502A)	Disable External Trigger
◆	W (8502A)	No Delay
●	Y0 (-06 Option only)	Echo mode off (Bit Serial IF)

In addition, the following instrument states are assumed at power on or Reset:

	Remote/Local	Local
	Offset	Zeroed
	V dc Zero	Zeroed or *
	Ohms Zero	Zeroed or *
	Cal Memory Factors	*
	Peak Values	Cleared
	Limits Values	Zeroed
	Ext. Ref/Scaling Values	1
●	8/16 Bit Mode (-07 Option only)	8 Bit

*Retained if Cal Memory Option -04 installed

Table 2A-1. Programming Instructions (cont)

PROGRAM SEQUENCE

When equipped with a remote interface option, the instrument is programmed through a sequence of commands ("command string") that will determine range, function, reading rate, etc. Examples of 5 possible command strings are:

1. V A R 2 S 5 F ?

- ? — Execute, trigger and transmit
- F — Slow filter, no time out
- S 5 — 2^5 samples/reading
- R 2 — 10 volt range
- V A — AC voltage

2. T D Y ?

- ? — Execute, trigger and transmit
- Y — Echo characters
- D — Turn display off
- T — Continuous line synchronized readings

3. K N U 6 . 3

- K N U 6 . 3 — Upper limit

K N L 6 . 2 U ,

- , — Execute
- U — Enter limits mode
- K N L 6 . 2 — Lower limit

4. Z R , S 5 $

- $ — Clears command string to preceeding "," "?" or "@"
- S 5 — 2^5 samples/reading
- , — Execute
- R — Auto range
- Z — Ohms

5. % G 1 ?

- ? — Execute, trigger and transmit
- G 1 — Get status and transmit on trigger
- % — Halt reading

Table 2A-1. Programming Instructions (cont)

All command string characters transmitted via the remote interface must be ASCII 7-bit upper case characters. A command string is a sequence of 1 to 31 characters. (For the 8505A and 8506A, a command string may have up to 59 characters.) Characters are classified as immediate, command or termination. The instrument may be placed in Remote mode by transmitting any character that the instrument will recognize from the remote controlling terminal.

- With the IEEE Interface installed, the REMOTE switch can only be used to select local mode if already in Remote.

REMOTE is the only front panel switch to remain active when in REMOTE mode; REMOTE may, however, be locked out by the local lockout command.

IMMEDIATE CHARACTERS

There are 5 immediate characters; each of these may be executed at any time and does not require a termination character.

(*) **Reset**

This immediate character will reset the instrument to the conditions described under INITIALIZATION.

- ◆ When transmitted, the reset character must not be followed by any other character for 3 seconds with the 8502A (2 seconds with the 8500A). Any carriage return or line feed following the reset character must be suppressed. The remote interface will be unable to accept programming characters during this time.

(%) **Halt**

The halt character is used to terminate the continuous mode and cause the instrument to wait for a command string. No other characters should precede the halt character if continuous mode is in effect. Upon receipt of the halt character, the transmission of readings is terminated immediately. The following trigger mode transitions will occur when halt is used:

From: Continuous Line Synchronous
To: Single Reading Line Synchronous

From: Continuous Asynchronous
To: Single Reading Asynchronous

(#) **Go To Local - Lock Out Remote**

- This character will command the instrument (Options -06 or -07 only) to enter local mode of operation and lock out the remote interface.
- The Remote mode may then be reentered by pressing the front panel REMOTE switch (for Option -06, -07). The Remote mode may not be reentered from the front panel when using the IEEE-488 Interface (Option -05).

Table 2A-1. Programming Instructions (cont)

**Go To Local-Lock Out Remote (cont)**

The state of the instrument, when changing from remote to local operation will be modified as follows:

1. Ohms fast mode will be ignored.

◆ 2. Scaling mode will not be in effect (8500A only).

◆ 3. If the high averaged samples per reading rate was in effect, the samples per reading will be set to 2^7 (8500A only).

The state of the instrument when changing from local to remote operation will be modified as follows:

1. Ohms fast mode (Z1) and continuous reading mode will be resumed if the DMM was in either mode when place into local.

2. Any error that occurred during local operation will be stored and available for recall.

! **High Speed Reading Mode**

● The "!" character can be used with the Parallel Interface (Option -07) (and with the IEEE-488 Interface Option -05 in the 8502A only). The High Speed Reading mode provides a shortened 3-byte binary two's complement format response representing the input to the DMM's A/D Converter. Speeds up to 500 readings per second are possible in this mode of operation.

True readings can be computed from this response using range and function dependent factors (refer to Fluke Application Bulletin 25).

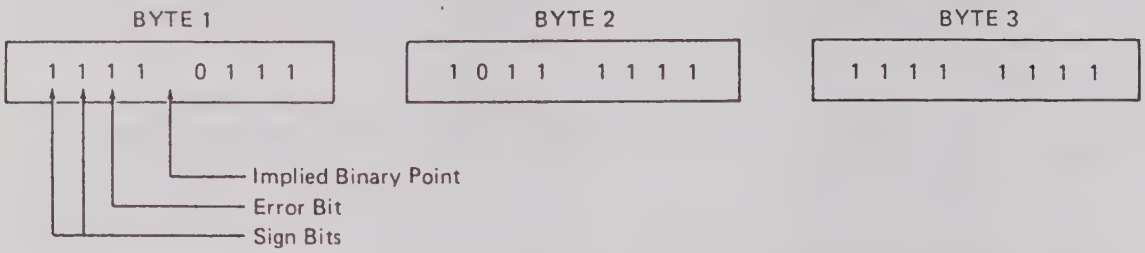
The High Speed Reading mode is suited to systems with very fast processors, to use with stored readings, or to applications not requiring direct numeric conversions (e.g., zero crossings or large deviations from a nominal value).

◆ Use of the "!" character will place the DMM in the High Speed Reading mode and trigger the first reading. Subsequent readings can be triggered by sending the "?" character. In addition, for the 8502A equipped with the -08A Option, subsequent readings can be triggered by sending the TTL pulse with the External Triggering Mode ("Q" or "Q1"). The High Speed Reading mode can be aborted at any time by transmitting a character other than "?" when a reading is to be triggered. The character sent in this case will do nothing more than cause the DMM to exit the High Speed Reading mode.

Table 2A-1. Programming Instructions (cont)

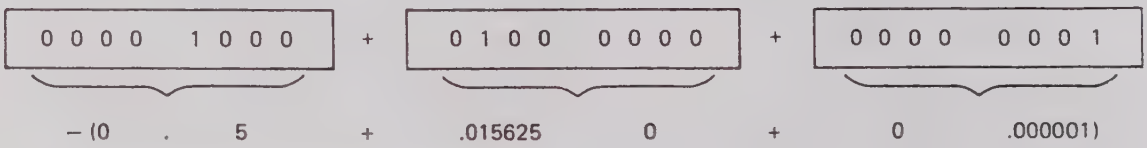
Voltage and Current Reading In "I"

The response data from the DMM will be in 3-byte format, as shown below, for each voltage or current reading. The first byte of this response contains sign and error bits, an implied binary point, and an implied scale factor of ten. Bytes 2 and 3 further define the reading. If the reading is negative, the sign bits will equal "1", and all three bytes must be two's complemented before conversion. If the error bit is equal to the complement of the sign bit, an error is defined.



In this example, the sign bits are "1" and the reading is negative. Since the complement of the sign bit does not equal the error bit ("1"), no error is defined.

To convert the response in this example, the two's complement must first be formed.



= 0.515626 X 10 (the implied scale factor)

Further conversion to calculate the true reading Rt necessitates multiplication of the A/D Converter reading (RAD) by the scale factor for the instrument's range and function.

$[R_t = R_{AD} \text{ X Scale Factor}]$

Ohms Readings In "I"

The procedure for measuring ohms in High Speed Reading mode is more complex. High Speed Ohms readings differ from Fast Ohms (Z1) readings; when using the "!" character, the DMM will not compute the true reading. This conversion must be performed by the user. Up to 500 readings a second are possible when using High Speed Ohms. Refer to OPERATING NOTES, provided with Option -05 and -07 for High Speed Ohms Reading procedures.

8/16 Bit Toggle

The "/" character is used to toggle between the 8-bit and the 16-bit mode. When this character is used to toggle from one mode to another, the immmediate and/or termination character must be placed in the least significant byte (LSB) of the programming word.

Table 2A-1. Programming Instructions (cont)

TERMINATION CHARACTERS

Termination characters cause the execution of a command string. They are normally placed at the end of each programming statement.

$ Clear the Command String

● (Normally used only with the Bit-Serial Interface -06 Option.)

This character is used to erase an incorrect programming entry from the command string buffer, deleting all characters issued back to, but not including, the preceding termination character. A new command string is then needed to modify the state of the instrument.

, Execute the Command String

This character is used to cause the execution of the previous command string. The instrument will then be in the defined state only; the character will not trigger a reading or produce a response from the instrument. When programming a string of characters, it is recommended that the execute character be used at frequent intervals; if an error is made, the string need then be cleared only back to the last execute character. This execute character is also required if a command string longer than 31 characters is used.

? Execute the Command String and Trigger

This character will cause three actions: any previously entered command string will be executed, a reading will be taken, and that reading will be transmitted through the remote interface. If a command string was not entered immediately preceding this character, the instrument will take and transmit a reading in the last defined state.

An exception occurs when a command string containing a "Get" command has been entered; the instrument will then respond with the value or status that was requested by the command string (no reading will be triggered).

When issuing a program string terminated by the "?" character, the "CR" and/or "LF" delimiter characters should be, but do not have to be suppressed. If an error occurs during the reading, a single "0", followed by a "CR", will be transmitted. At this point, status should be requested to determine the cause of the error.

@ Execute, Trigger, and Interrupt when Ready

This character is used to trigger a reading and generate an interrupt when the reading is complete.

Table 2A-1. Programming Instructions (cont)

@ Execute, Trigger, and Interrupt when Ready (cont)

- To provide the interrupt, the Bit-Serial Interface (Option -06) and the Parallel Interface (Option -07) transmit a single "CR". The IEEE-488 Interface (Option -05) provides an interrupt by generating a service request (SRQ).

The reading triggered by the "@" character can be obtained by inserting a "G" (get) command in the following command string (terminated by a "?").

The "@" character and the IEEE-488 Bus command "Group Execute Trigger" perform the same function.

COMMAND CHARACTERS

Command characters are classified within the following five groups:

1. FUNCTION
2. RANGE
3. MODIFIERS
4. CONTROL
5. MEMORY

FUNCTION COMMAND CHARACTERS

There are 7 function command characters. Whenever one of these characters is used, the state of the instrument will be changed as follows:

RANGE	Auto
MODIFIERS	Offset, Scaling, Limits, Peaks modes are turned off; stored values for these modes are retained.
MEMORY, CONTROL	Unchanged

If a function is selected requiring an optional module which is not loaded, the function of the instrument will be undefined, and the error code will be set to 19.

V DC Volts

V A AC Volts

C DC Coupled AC Volts

I DC Current

I A AC Current

Table 2A-1. Programming Instructions (cont)

[Z] **Ohms**

[Z] [1] **Fast Ohms**

The Z1 character will place the instrument into the ohms function and the fast ohms mode. In normal ohms operation, the unknown resistor value Rx is computed from the following measurements:

V1-V2: the voltage across an internal precision resistor (Rr)

V0: the voltage across the unknown resistor (Rx).

The value of Rx is then computed with Ohm's Law:

$$Rx = Rr \frac{V0}{V1\text{-}V2}$$

Fast Ohms mode differs in that the value of $\frac{Rr}{(V1\text{-}V2)}$ is stored as a constant. The instrument will the find Rx by measuring V0 and multiplying this constant. The constant will change with a function change, range change or overload condition.

NOTE

Fast ohms ("Z1") differs from HIGH SPEED READING ("!"). When using "!" for ohms measurement, Rx is not computed by the DMM.

RANGE COMMAND CHARACTERS

The nine range commands specify the following maximum values by function.

	DC VOLTS	VA or C AC VOLTS	I or IA DC or AC CURRENT	Z or Z1 OHMS
[R]	Auto	Auto	Auto	Auto
[R] [0]	312 mV	Auto	312 μA	31.25Ω
[R] [1]	2.5V	2.5V	2.5 mA	250Ω
[R] [2]	20V	20V	20 mA	2 kΩ
[R] [3]	160V	160V	160 mA	32 kΩ
[R] [4]	1200V	1000V	1.28A	256 kΩ
[R] [5]	Auto	Auto	Auto	4.096 MΩ
[R] [6]	Auto	Auto	Auto	32.768 MΩ
[R] [7]	Auto	Auto	Auto	262.144 MΩ

Table 2A-1. Programming Instructions (cont)

MODIFIER COMMAND CHARACTERS

SAMPLES PER READING COMMAND CHARACTERS

The modifier command character "S" or "H" specifies the number of samples taken per reading. The times shown for these characters are approximate digitizing times per reading for 60 Hz line synchronous operation in dc volts, ac volts or current function.

S 0	2^0 = 1 Sample/Reading (4 ms)
S 1	2^1 = 2 Samples/Reading (8 ms)
S 2	2^2 = 4 Samples/Reading (17 ms)
S 3	2^3 = 8 Samples/Reading (33 ms)
S 4	2^4 = 16 Samples/Reading (67 ms)
S 5	2^5 = 32 Samples/Reading (134 ms)
S 6	2^6 = 64 Samples/Reading (267 ms)
S 7	2^7 = 128 Samples/Reading (534 ms)
H 0	2^8 = 256 Samples/Reading (1.1s)
H 1	2^9 = 512 Samples/Reading (2.1s)
H 2	2^{10} = 1,024 Samples/Reading (4.3s)
H 3	2^{11} = 2,048 Samples/Reading (8.5s)
H 4	2^{12} = 4,096 Samples/Reading (17.1s)
H 5	2^{13} = 8,192 Samples/Reading (34.1s)
H 6	2^{14} = 16,384 Samples/Reading (68.3s)
H 7	2^{15} = 32,768 Samples/Reading (137s)
H 8	2^{16} = 65,536 Samples/Reading (273s)
H 9	2^{17} = 131,072 Samples/Reading (546s)

Table 2A-1. Programming Instructions (cont)

FILTER COMMAND CHARACTERS

The "F" character is used to specify the type of filtering and the enabling of a time-out (for the filter settling time). This time-out causes a delay between a trigger command received and the actual reading taken. In the continuous trigger modes, the time-out will occur before each reading is initiated. The following "F" modifier command characters are used:

F	**Slow filter, time-out disabled.**
F 0	**Fast filter, time-out disabled.**
F 1	**Bypass filter.**
F 2	**Slow filter, time-out enabled (approximately 500 ms).**
F 3	**Fast filter, time-out enabled (approximately 50 ms).**

TRIGGER COMMAND CHARACTERS

The "T" characters specify the instrument's trigger mode. These characters determine whether samples taken are line synchronous (every 4 or 5 ms) or line asynchronous (approximately every 1.7 ms), whether single or continuous readings are to be taken.

T	**Continuous reading mode/line synchronized.**
T 0	**Single reading mode/line synchronized.**
T 1	**Continuous reading mode/line asynchronous.**
T 2	**Single reading mode/line asynchronous.**

NOTE

When line asynchronous modes are selected, the display will be turned off to save time; the front panel switches are then ignored.

◆ When in the continuous mode, any character (except "%" HALT) will be ignored by the instrument (8502A).

When in the Single Reading mode ("T0" or "T2"),and IEEE Group Execute Trigger command, a "?" or "@" character, or a TTL trigger (for the 8502A-08A) must be sent for each reading.

With the Continuous Reading mode ("T" or "T1"), use of the "GET" command, "?", "@" or a TTL trigger will start continuous readings.

When each reading is accepted by the instrument controller, the next reading will be started. An exception to this sequence occurs in the "J1" Suppress Output mode; the next reading will now be taken immediately, without waiting for the output to the controller.

NOTE

The front panel display does not update in this mode unless the controller asks for a reading.

Use of the "%" character will halt the Continuous Reading mode and cycle the unit back to the Single Reading mode.

OFFSET COMMAND CHARACTERS

The "P" command characters specify whether an offset will be subtracted from a reading. The offset value may be entered by storing either a previous reading or a numerically entered offset.

- When storing readings, the 8500A will store the unprocessed reading, and the 8502A will store the displayed value.

Offset values may range from $\pm 1 \times 10^{9}$ to $\pm 1 \times 10^{-9}$ (including 0.0).

[P] **Offset subtracted (ON).**

[P] [0] **Offset not subtracted (OFF).**

EXTERNAL REFERENCE AND SCALING COMMAND CHARACTERS

The "X" command characters select External Reference or Scaling mode. Either mode is valid for any function and range. In External Reference mode, readings are divided by the signed magnitude of the external reference voltage. In Scaling mode, readings are divided by a numerically entered scale factor or by a previously read value.

[X] **External Reference On, Scaling Off**

The "X" External Reference mode uses the external reference voltage (Vxref) to divide the measured voltage. Vxref is measured during each reading cycle.

- Minimum Vxref = ±0.0001V or the input divided by the maximum display with the volts range, whichever is greater (8500A only).
- For the 8502A, the minimum Vxref is the input divided by 10^{9}.

Maximum Vxref = ±40V between Ext Ref Hi and Lo terminals, providing neither terminal is greater than ±20V relative to the Sense Lo or Ohms Guard Terminals.

X 0	**External Reference Off, Scaling Off**
X 1	**External Reference Off, Scaling On**

The "X1" Scaling mode will divide all readings by a previously taken external reference voltage or by a previously entered numeric scale factor. The read valued may not be used as a scaling factor.

NOTE

The 8502A can store the external reference voltage and the numerical scale factor separately. The 8500A can only store one or the other, not both.

- Minimum scaling factor = the same as the minimum Vxref, for the 8500A.
- For the 8502A minimum = 10^{-9}. Factors less than this will be set to 0, which is not a valid scale factor.

Maximum scaling factor = ±100 (8500A), or Input/Max Scale factor $<10^{-9}$ (8502A).

NOTE

The "X" and "X1" modes are mutually exclusive.

LIMITS AND PEAKS COMMAND CHARACTERS

The "U" command characters specify selection of Limits or Peaks modes.

U	**Limits Testing On**

When this command character is sent, each instrument reading is compared to upper and lower limits. Limit values must be entered separately with a keep command (refer to KEEP COMMAND CHARACTERS). The output format from the instrument (when given a "G" command) is as follows:

"0" is transmitted for a reading within limits.

"1" is transmitted for a reading greater than the upper limit.

"-1" is transmitted for a reading less than the lower limit.

"2" is transmitted if an error occurs (e.g., overranging).

U 0	**Disable Limits and Peak Mode(s)**
U 1	**Save Highest and Lowest Values (Peaks On)**

Previous peak values are erased from memory whenever the "U1" command character is programmed.

U 1	**Save Highest and Lowest Values (Peaks On) (cont)**	◆ For the 8500A, storage of limit and peak values are mutually exclusive. For the 8502A, limit and peak values can be held in memory simultaneously.

NOTE

Limits are applied after all other modifier operations (Scaling, Offset, etc.) have been performed.

CONTROL COMMAND CHARACTERS

Output Format

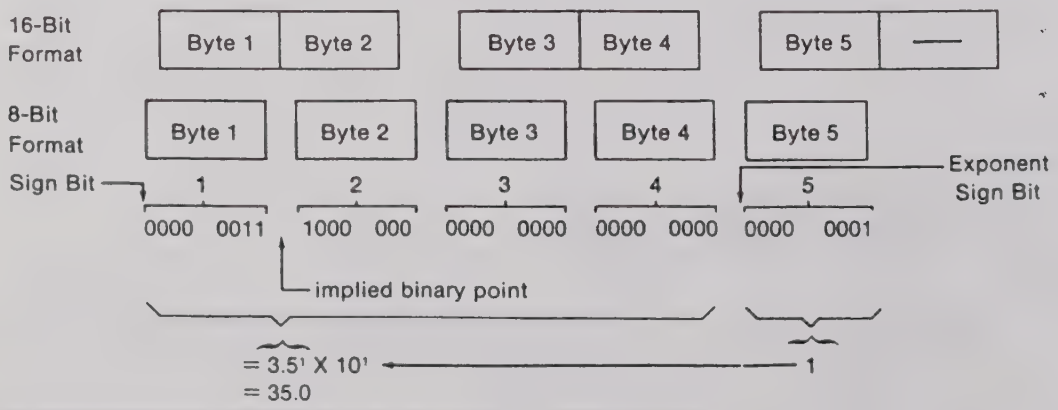
The "B" characters activate binary or ASCII output format.

B	**Single Byte Binary Format**	
B 0	**Single Byte ASCII Format**	
● B 1	**Binary 16-Bit Parallel**	"B1","B2" used with Paralled ASCII Interface (Option -07) only.
● B 2	**16-Bit Parallel**	

The front panel DMM display is turned on when the ASCII mode is entered and off when the binary mode is entered.

The Binary Output Format

The binary output format consists of five bytes. The first four bytes comprise a 32-bit binary two's complement fixed point number. An implied binary point for this number is located between the first and second bytes. The first 8-bit byte thus serves as the integer portion. The 24 bits of the next 3 bytes serve as the binary fraction. Additionally, since this format cannot be used to hold the entire range of possible values for the DMM, a fifth byte is used as an exponent. This exponent is a two's complement binary number representing the decimal exponent of the binary fixed point number defined by the first 4 bytes. An exception occurs in Limits testing; the response will then be single byte binary two's complement number.

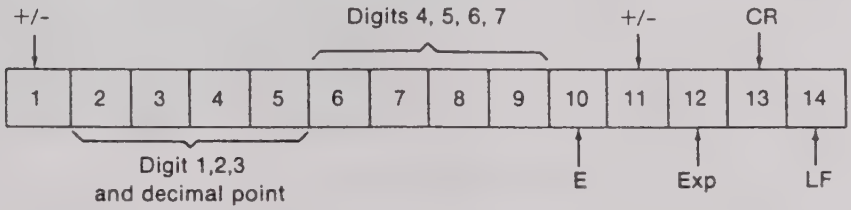


NOTE

In dc volts and ac volts, the exponent is always 1. In dc and ac current, the exponent is always -2. The exponent is range dependent in ohms function (1 for ohm ranges, 4 for kohm ranges, and 7 for Mohm ranges).

Errors will be indicated by 5 bytes of 0.

ASCII Data Output Format



The seventh digit in the ASCII format corresponds to the "Cal" or HIRES digit of the front panel display. In some ranges and functions (e.g., 100 mV dc) this digit is permanently zeroed since it exceeds the resolution of the instrument. (When in the "Cal" or HIRES mode, the front panel will display the value of the reading rounded to six significant digits.)

DISPLAY CONTROL

The "D" command characters turn the DMM front panel display on or off.

D **Display Off**

D 0 **Display On**

When the "D0" command is used, the instrument will no longer interrogate any of the front panel switches (local lockout). The display will be turned On when the ASCII output format is commanded.

LOCAL LOCKOUT CONTROL

The "L" command characters select the local lockout condition, in which the display remains activated while none of the front panel switches affect the instrument.

L **Local Lockout On**

L 0 **Local Lockout Off**

ECHO COMMAND CHARACTERS

● **(used with Bit Serial Option -06 only)**

Y **ECHO ON (Full-Duplex)**

Y 0 **ECHO OFF (Half-Duplex)**

LINE FEED CONTROL COMMAND CHARACTERS

J	**Suppress Line Feed Character**	This character suppresses the LF character normally sent at the end of a response line.
J 0	**Transmit Line Feed Character**	This character disables the "J" character; the "LF" character will be sent.
J 1	**Suppress Output of Readings**	◆ In the 8500A, use of J1 will suppress all output from the DMM. In the 8502A, use of J1 will suppress output with the following exceptions: Service Request (SRQ), status, recalled values. While in the J1 mode, use of the recall command "G ?" will retrieve a reading. Use of "J" or "J0" will exit the "J1" mode.

CALIBRATION CONSTANT

When the Calibration Memory (Option -04) module is installed, the "M" character will inhibit the adjustment of readings by the Calibration Memory correction factor. A slight increase in the speed of readings will result.

M	**Inhibit Calibration Memory Factors**
M 0	**Enable Calibration Memory Factors**

TRIGGER COMMAND CHARACTERS

◆ This set of command characters is available for the 8502A with the Isolator Option -08A.

Q	**Activate External Triggering Mode, Interrupt when Ready**	This character enables the External Triggering mode. Any external TTL trigger then initiates a reading and interrupts when ready (SRQ).
Q 0	**Deactivate External Triggering Mode**	
Q 1	**Activate External Triggering Mode, Transmit when Ready**	The Q1 character also enables External Triggering mode. Any external TTL trigger initiates and transmits a reading.

NOTE

The "?" and "@" characters remain operative during External Triggering.

♦ EXTERNAL TRIGGER DELAY COMMAND CHARACTERS
(-08A with 8502A only)

The "W" command characters select the amount of delay between the external trigger signal and the initiation of the reading.

W	No Delay
W 0	2.083 ms
W 1	4.166 ms
W 2	8.332 ms
W 3	16.66 ms
W 4	33.33 ms
W 5	66.66 ms
W 6	133.3 ms
W 7	266.6 ms
W 8	533.2 ms
W 9	1.066s
W 1 0	2.133s
W 1 1	4.266s
W 1 2	8.532s
W 1 3	17.06s
W 1 4	34.13s
W 1 5	68.26s

MEMORY COMMAND CHARACTERS

STORE

The "K" (Keep) command characters specify the storing of a reading or numeric entry.

[K] **Store Last Reading as Offset**

◆ The 8500A will store the unprocessed reading, whereas the 8502A will store the displayed reading.

[K] [0] **Store Last Voltage Taken as VDC Zero (on R0 Only)**

[K] [1] **Store Last Reading as Ohms Zero (on R0 Only)**

[K] [N] [P] **Store Numeric Value Following as Offset**

[K] [N] [X] **Store Numeric Value Following as Scaling Factor**
(Note: The read value may not be stored as a Scaling Factor.)

[K] [N] [U] **Store Numeric Value Following as Upper Limit**

[K] [N] [L] **Store Numeric Value Following as Lower Limit**

Offsets, Scaling Factors, Upper and Lower Limits may be entered via the "KN" command characters, followed by one of the modifier characters "P", "X", "U" or "L" and the numeric value (on ASCII string of numeric characters, and optional sign, decimal point and signed decimal exponent digit in "E" notation).

Examples of legal numeric strings are:

[K] [N] [P] [1] [0]
Keep Numeric offset of 10.0

[K] [N] [X] [1] [0] [.] [3] [E] [-] [1]
Keep numeric scaling factor of 10.3×10^{-1} or 1.03

[K] [N] [U] [7] [.] [6] [E] [4]
Keep numeric upper limit of 7.6×10^{4}

[K] [N] [L] [-] [1] [2] [3] [.] [4] [5] [6] [E] [+] [0]
Keep numeric lower limit of −123.456

An example of an illegal numeric string is:

Exponent is limited to one signed integer digit, in this case the exponent would be -1 and the "3" would be ignored.

NOTE

Numeric entries are limited to the maximum display value. These values are:

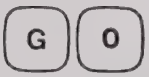
+1.00000 E +9 to +1.00000 E -9, and -1.00000 E -9 to -1.00000 E +9

Numbers less the ±1.00000 E -9 are treated as zero.

RECALL

The "G" (Get) command characters specify the recall of a reading, a numeric entry or a status. Each "Get" command must be followed by a "?" termination character. The following memory "Get" commands may be used:

Recall Previous Reading and Send on Next Trigger

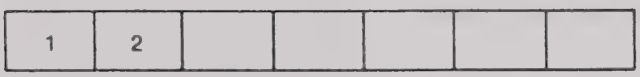


Recall DC Zero and Send on Next Trigger

Recall Status and Send on Next Trigger

Status information from the DMM may be obtained with the command character "G1?". The status response will be returned in the following seven character format.

Error Codes



Characters 1 and 2 define error code status. Each error code contains two digits: those codes with a zero for the first digit are related to remote operation only. All other codes contain the same second digit as the DMM's front panel error codes.

- 00 No Error
- 06 System Error
- 07 Illegal Numeric Entry
- 08 Remote Command String Error
- 09 Remote Overrange
- 10 V DC Zero/Ohms Zero Error
- ◆ 11 Offset Error (8500A) Store during Overrange (8502A)

Error Codes (cont)

12 Filter Module Faulty or not installed
13 DC Signal Conditioner Module Faulty or not installed
14 Excessive voltage present at terminals for Ohms/Current Measurement
15 Fast A/D Converter Faulty or not installed
16 Numeric Display Overflow
17 Magnitude of External Reference Input >20V
18 Controller Module Faulty
19 Function Module selected not installed

Range Codes

		3				

The third character of the status response contains the following range information:

0 100 mV dc, 100 μA, 10Ω
1 1V dc, 1V ac, 1 mA, 100Ω
2 10V dc, 10V ac, 10 mA, 1kΩ
3 100V dc, 100V ac, 100 mA, 10 kΩ
4 1000V dc, 1000V ac, 1A, 100 kΩ
5 1 MΩ
6 10 MΩ
7 100 MΩ

Sample Codes

			4			

The fourth status response character contains sample information identified by the following codes:

0 1 Sample per Reading
1 2 Samples per Reading
2 4 Samples per Reading
3 8 Samples per Reading
4 16 Samples per Reading
5 32 Samples per Reading
6 64 Samples per Reading
7 128 Samples per Reading or Greater

Function Codes

				5	<CR>	<LF>

The fifth response character identifies function:

0 DC Volts
1 AC Volts
2 DC Amps
3 AC Amps
4 Ohms
5 DC Coupled AC Volts
7 Function Not Defined

G N P	Recall Offset and Send on Next Trigger
◆ G N X	Recall External Ref or Scaling Factor and Send on Next Trigger (8500A) Recall Scaling Factor (8502A)
◆ G N R	Recall External Reference Factor and Send on Next Trigger (8502A)
G N U	Recall Upper and Send on Next Trigger
G N L	Recall Lower Limit and Send on Next Trigger

NOTE

The instrument will replay to "GNU" or "GNL" by transmitting the stored limit value.

G N Q	Recall Lowest (Peak) Value Found and Send on Next Trigger
G N W	Recall Highest (Peak) Value Found and Send on Next Trigger

The following discussion relates remote operation features available with the 8505A and the 8506A to existing documentation for remote operation of the 8500 series multimeters. The additional features for the 8505A and the 8506A are presented in this discussion in the same sequence as they would appear in the "Programming Instructions" table (Table 2A-1).

Most of the items documented in this table supplement features available with the 8502A and 8502A/AT. Incompatibilities have been kept to a minimum. Therefore, programs designed for the 8502A are generally compatible with the 8505A and the 8506A, and 8502A/AT programs are generally compatible with the 8506A. The few areas that are not compatible are briefly described below. Refer to appropriate areas in this table for a more detailed description.

1. High Speed Mode (!): Some High Speed mode scaling factors have been changed. Also, use of the reset command (*) causes the multimeter to both exit High Speed mode and perform a normal reset.

2. Range Commands: Full scale points and autoranging points have been changed in several instances.

3. Store Zero Commands (K0, K1): In the 8505A/8506A, the temporary zero correction values are set to 0 when the instrument is reset or powered up (similar to the 8502A without the calibration memory option). In the 8502A with the calibration memory option, resetting the instrument does NOT clear the stored zeros.

INITIALIZATION

CAUTION

Interruption of input power could affect Calibration Memory entries when the multimeter is in Calibration mode. Do not cycle input power to the multimeter when Calibration mode is activated. If power is ON, verify that the AVG/(CAL) annunciator is not flashing before cycling power to OFF. From the remote, Calibration mode status can be verified with the G5 command (response of 0 = mode off, response of 1 = mode on). If power is OFF, verify that the rear panel Calibration switch is off before cycling power to ON.

Both the 8505A and the 8506A assume the same configuration at power up as that described for 8502A, with the following exceptions:

1. The Average mode is disabled (O0).

2. Calibration Memory factors are retained at all times. These factors include zero corrections for each range in dc volts and ohms functions, gain corrections for each range in each function, and the calibration date (or instrument identification) number.

3. External Reference at power up or reset is used as temporary storage for the multimeter software version number. The GNR command can then be used to recall this number. Any use of the X command subsequent to power-up or reset replaces this number with the value applied at the external reference inputs.

4. Zero mode is enabled with all temporary zero correction values set to 0.

HIGH SPEED MODE

Selection of the High Speed mode sets the following conditions:

1. The "!" command both enters the High Speed mode and triggers a reading.

2. Use of any character (or bit pattern) other than "?" causes the multimeter to exit the High Speed mode. Use of "*" causes the multimeter to both exit the High Speed mode and perform a normal reset. The character used to exit High Speed mode must be sent by itself. Any commands to be executed after exiting High Speed mode must be sent in a separate transmission (i.e., in a separate statement in the instrument controller program).

3. Selection of High Speed mode specifies the binary output format. Any previously selected output format is restored once High Speed mode is exited.

4. The multimeter front panel display is blank while High Speed mode is on. The previously selected display mode is restored once High Speed mode is exited.

5. High Speed mode specifies asynchronous, single trigger mode (T2). The previously selected trigger mode is restored once High Speed mode is exited.

The high speed reading mode ("!") cannot be used for any ac volts function (normal, enhanced, or high accuracy) with the 8506A.

Voltage and Current Reading in "I"

The following scale factors are used:

FUNCTION	UNITS	RANGE				
		0	1	2	3	4
DC Volts (V)	V	1/100*	1/10*	1	64/10*	64
DC Amps (I)	mA	-1/80*	-1/10*	-8/10*	-64/10*	-512*
AC Volts (8505A only)	V	n/a	1/8	1	8	64
AC Amps (8505A only)	mA	1/64	1/8	1	8	64
*Differs from 8502A						

FUNCTION COMMAND CHARACTERS

The 8505A uses the same function command characters as those listed. The "C" command (dc coupled ac volts) can only be used when the True-RMS Converter (Option -09A) is installed. When an 8505A function is changed, the multimeter is configured as follows:

1. If the same function is re-selected, the multimeter assumes autoranging and retains all other existing modes and stored values.

2. If a new function is selected, the following configuration is set:

   a. Autoranging (R) is set.

   b. The existing trigger mode, sample, and filter are retained. However, if Average mode was previously on, it is turned off, sample is set to S7 and filter is set to F0.

   c. Offset, External Reference, Scaling, Limits, and Peaks are turned off (P0, X0, U0 respectively), with all respective values retained.

   d. Zero mode is toggled off if a function other than dc volts (V) or ohms (Z) is selected. If dc volts (V) or ohms (Z) is reselected, the Zero mode state (on or off) is restored to that in effect the last time the function was selected. The values of the temporary zeros are stored until the instrument is reset or powered off, or until new temporary zeros are stored.

   e. Calibration mode is on or off (as determined by the Calibration Switch setting) and gain correction factors are enabled (M0).

When an 8506A function is changed, the multimeter assumes a configuration defined by the variety of both old and new functions. One variety includes dc volts (V), ohms (Z), and dc amps (I). The second variety includes all ac volts functions (VA, VA1, VA2, C, C1, and C2). Four types of configuration change are therefore possible. Each of these changes resembles that detailed above for the 8505A, with the following exceptions:

1. Initial function was V, Z, or I — New function is V, Z, or I:

   The 8505A configuration is used.

2. Initial function was V, Z, or I — New function is ac or ac+dc volts:

   a. Filter mode off (F0) is set.

   b. No sample setting is allowed.

   c. Zero mode is off.

3. Initial function was ac or ac+dc volts — New function is V, Z, or I:

   a. Filter mode on (F) or off (F0) is retained.

   b. Sample S7 is set.

4. Initial function was ac volts — New function is ac volts:

   a. If the initial and new functions are both ac volts (or both ac+dc volts), manual ranging mode is retained at the same range, or autoranging is retained (starting at the same range).

   b. If the change is between an ac volts function (VA, VA1, VA2) and an ac+dc volts function (C, C1, C2), autoranging is automatically enabled.

   c. For all types of change (ac to ac, ac+dc to ac, ac to ac+dc, or ac+dc to ac+dc), Averaging mode (extended resolution) and all other modes and values are retained. No sample change is allowed in any 8506A ac volts function.

The following commands are used when initially selecting an 8506A ac volts function:

1. V A : V AC Normal
2. V A 1 : V AC Enhanced
3. V A 2 : V AC High Accuracy
4. C : V AC Normal (DC Coupled)
5. C 1 : V AC Enhanced (DC Coupled)
6. C 2 : V AC High Accuracy (DC Coupled)

NOTE

AC volts function commands used with the 8502A/AT are compatible with the 8506A. However, the six function commands mentioned above allow for faster, direct entry into the desired 8506A ac volts mode.

If the 8506A is already in an ac volts function, an abbreviated command can be used when selecting either of the other two ac volts functions. When selecting between ac or dc coupling for ac volts, the full command string mentioned above must be used. The abbreviated commands are as follows:

1. S 0 : V AC Normal
2. S 1 : V AC Enhanced
3. S 2 : V AC High Accuracy

RANGE COMMAND CHARACTERS

The nine range commands used with the 8505A or 8506A specify the full scale values by function as follows:

	DC VOLTS (V)	AC VOLTS 8505A	AC VOLTS 8506A	DC AMPS (I)	AC AMPS (IA) 8505A	OHMS (Z or Z1)
R	Auto	Auto	Auto	Auto	Auto	Auto
R 0	200 mV	Auto	125 mV	250 μA	312.5 μA	20 ohms
R 1	2V	2.5V	400 mV	2.0 mA	2.5 mA	200 ohms
R 2	20V	20V	1.25V	16 mA	20 mA	2 kohms
R 3	128V	160V	4V	128 mA	160 mA	20 kohms
R 4	1200V	1000V	12.5V	1.28A	1.28A	200 kohms
R 5	Auto	Auto	40V	Auto	Auto	4.1 Mohms
R 6	Auto	Auto	125V	Auto	Auto	35 Mohms
R 7	Auto	Auto	600V	Auto	Auto	265 Mohms

Resolution available for remote readings is as follows:

FUNCTION	RANGE	ASCII DIGITS*	
		STANDARD MODE	AVERAGING OR CALIBRATION MODE
DC Volts (V)	100 mV (R0)	6½ (5½)	6½
	1V (R1)	6½	6½
	10V (R2)	6½	7½
	100V (R3)	6½	6½
	1000V (R4)	6½	6½
Ohms (Z)	10 ohms (R0)	6½	6½
	100 ohms (R1)	6½	6½
	1 kohm (R2)	6½	6½
	10 kohms (R3)	6½	6½
	100 kohms (R4)	6½	6½
	1 Mohm (R5)	6½	6½
	10 Mohms (R6)	6½	6½
	100 Mohms (R7)	6½	6½
DC Amps (I)	100 μA (R0)	6½ (5½)	6½
	1 mA (R1)	6½	6½
	10 mA (R2)	6½	6½
	100 mA (R3)	6½	6½
	1A (R4)	6½	6½
AC Amps (8505A only)	100 μA (R0)	5½	5½
	1 mA (R1)	6½	6½
	10 mA (R2)	6½	6½
	100 mA (R3)	6½	6½
	1A (R4)	6½	6½
AC Volts (VA) or AC + DC (C) (8505A only)	1V (R1)	6½	6½
	10V (R2)	6½	6½
	100V (R3)	6½	6½
	1000V (R4)	6½	6½

FUNCTION	RANGE	ASCII DIGITS*	
		STANDARD MODE	AVERAGING OR CALIBRATION MODE
AC Volts (VA, VA1, VA2) or AC + DC (C, C1, C2) (8506A only)	100 mV (R0)	6½ (5½)	6½
	300 mV (R1)	6½ (5½)	6½
	1V (R2)	6½	6½
	3V (R3)	6½	6½
	10V (R4)	6½	6½
	30V (R5)	6½	6½
	100V (R6)	6½	6½
	500V (R7)	6½	6½

*Resolution in binary mode is generally the same as in ASCII mode. Differing resolution in binary mode is shown in parentheses.

SAMPLES PER READING COMMAND CHARACTERS

Use of the sample commands is modified as follows:

1. With the 8505A, samples-per reading can be set with command S, followed by one or two digits (0-17). Digits greater than 17 cause a command string error (08). The H command can still be used, but the multimeter recognizes only one following digit (0-9, corresponding to S8 through S17 respectively).

2. With the 8506A (dc volts, ohms, dc amps only), samples-per-reading can be commanded in the manner described above.

3. With the 8506A set for ac volts, no sample changes are allowed. Therefore, commands S0 through S17 (or H0 through H9) cannot be used for sample settings when the 8506A is set for ac volts normal, enhanced, or high accuracy. However, the first three commands (S0, S1, S2) are used when commanding ac volts functions as follows:

   a. S0 commands ac volts normal. When initially commanding an ac volts function, only VA (for ac coupling) or C (for dc coupling) need be used. When the multimeter is already set for either of the other two ac volts functions, ac volts normal can be selected by using S0 only.

   b. S1 commands ac volts enhanced. When initially commanding an ac volts function, VA1 (for ac coupling) or C1 (for dc coupling) must be used. when the multimeter is already set for either of the other two ac volts functions, ac volts enhanced can be selected by using S1 only.

   c. S2 commands ac volts high accuracy. When initially commanding an ac volts function, VA2 (for ac coupling) or C2 (for dc coupling) must be used. when the multimeter is already set for either of the other two ac volts functions, ac volts high accuracy can be selected by using S2 only.

FILTER COMMAND CHARACTERS

Any filter command is acceptable for the 8505A or the 8506A (in V, Z, or I only). However, when Average mode is enabled, filter F is initially selected and can only be changed to F2 or re-selected. Any other filter selection (F0, F1, or F3), while accepted by the multimeter, sets the Average mode disabled and the sample at S7.

When the 8506A is in an ac volts function, only filter F0 (set at new function selection) or F (subsequently selected for inputs less than 40 Hz) is allowed.

TRIGGER COMMAND CHARACTERS

When the multimeter (8505A or 8506A) is in a continuous trigger mode (T or T1), the reset command (*) causes a normal multimeter reset. All other commands are buffered and examined only when the halt command (%) is sent.

With any trigger mode, no command string is examined until the existing reading or recalled value is returned. Any reading or recall value commanded (but not yet returned) can be discarded by sending the halt (%) command. If a continuous trigger mode (T or T1) is in effect when (%) is sent, the multimeter configuration is changed to single trigger mode (T0 or T2), and any buffered commands (with a terminating character) are executed.

AVERAGING COMMAND CHARACTERS

With the 8505A (all functions) and the 8506A (dc volts, ohms, dc amps only), the "O" character is used to command a preset sample and filter combination for each function and range to optimize accuracy and stability. Averaging also provides an extra digit of resolution in several ranges (as defined under RANGE COMMAND CHARACTERS). The following commands are available:

1. O: Averaging mode enabled.
2. O0 : Average mode disabled.

Enabling of Average mode in the situations defined above sets the multimeter to sample S10 and filter F. With Average mode enabled, samples S11-S17 or filter F2 can also be selected. Disabling of Average mode changes the sample and filter again and occurs under any of the following circumstances:

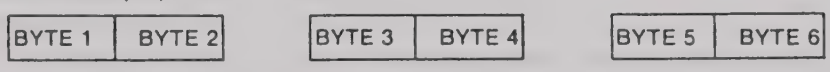
1. Command O0 is sent. Averaging mode is disabled. The sample is set to S7 and the filter is set to F0.
2. The function is changed. The sample is set to S7 and the filter is set to F0. If an ac volts function is initially selected with the 8506A, only filter F0 is set. If a change is made between 8506A ac volts functions (VA, VA1, VA2, C, C1, C2), Averaging (extended resolution) is retained.
3. A sample or filter not allowed in Average mode is commanded. If S0-S9 is commanded, Average mode is disabled, the new sample setting is accepted and the filter is set to F0. If a filter other than F or F2 is selected, Average mode is disabled, the new filter is accepted and the sample is set to S7.

With the 8506A set for any of the ac volts functions, Average mode is not available. However, the O or O0 command can still be used to enable or disable extended resolution (as defined under RANGE COMMAND CHARACTERS). In this situation, only the sample and filter restrictions defined by the 8506A ac volts functions are applicable. No sample change can be made. Only filter F0 or F (for input signals less than 40 Hz) can be selected. If a sample change is attempted or an unallowed filter is commanded, a momentary error is set and extended resolution is retained. Extended resolution in 8506A ac volts functions is disabled if the O0 command is sent. If a change is made between ac volts functions, extended resolution is retained with the existing filter mode. If dc volts, ohms, or dc amps is selected, extended resolution (Average mode) is disabled, the filter is not changed, and the sample is set to S7.

Whenever the "O" character is used (8505A or 8506A - any function), the multimeter responds with the following output format:

BINARY OUTPUT FORMAT

16-Bit Format (B1):



8-Bit Format (B):

Example:

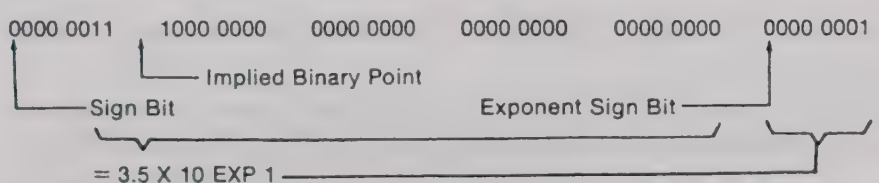
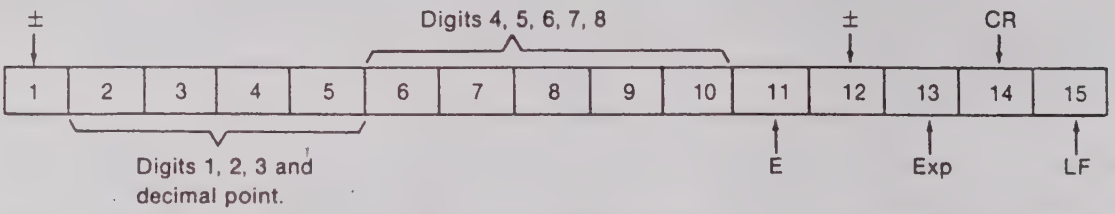


Table 2A-2. Programming Instructions (8505A, 8506A) (cont)

ASCII OUTPUT FORMAT



Digit 8 is used only on the 10V dc range to yield 7½ digit resolution. On all other ranges and functions, 6½ digit resolution is used and digit 8 is set to 0.

OFFSET COMMAND CHARACTERS

When storing the previous reading as an offset, both the 8505A and the 8506A use the displayed value in the same manner as does the 8502A.

LIMITS AND PEAKS COMMAND CHARACTERS

When Limits testing is enabled (U), an error is identified by either of the following responses:

1. The standard error response message (programmed with the K3 command) is normally returned.
2. If no such standard error response message has been programmed since the last power-up or reset, a "2" is returned to identify an error occurring during limits testing.

CONTROL COMMAND CHARACTERS

ASCII Data Output Format

Digit 7 is used with the 8505A and 8506A whenever 6½ digits of resolution are available. If 5½ digits are available, digit 7 is not needed and is consequently set to 0.

CALIBRATION CONSTANT

The Calibration Memory is a standard feature of the 8505A and 8506A. Therefore, the M and M0 commands may be used at any time to inhibit or enable all Calibration Memory gain correction factors:

M: inhibit all calibration gain correction factors.
M0: enable calibration gain correction factors.

The M1 and M2 commands may be used to inhibit or enable the temporary zero correction factors stored with the K0 and K1 commands (V DC and OHMS only). This has the same effect as turning the Zero mode off and on with the ZERO push button, except the M2 command does not store zeros:

M1: inhibit zero correction values (turn Zero mode off).
M2: enable zero correction values (turn Zero mode on).

The temporary zero correction factors are applied in dc volts (V) or ohms (Z) whenever the M2 command is in effect (i.e., whenever Zero mode is on). When the multimeter is powered-up or reset, the Zero mode is turned on and the temporary zero correction factors are reset to 0. During normal operation (Calibration mode off), the "permanent" zero correction factors in Calibration Memory are always in effect, and are not affected by the M1 and M2 commands.

Calibration Memory allows for software calibration of all functions and is fully described in Appendix 7B. Although software calibration procedures are not discussed here, the following considerations must be observed if Calibration mode is turned on (the Calibration mode is enabled or disabled with the rear panel Calibration Switch when the multimeter is in local control):

1. Calibration correction factors are always applied to readings unless the M command is sent. This is true whether Calibration mode is on or off.
2. When Calibration mode is on, the M1 and M2 commands enable and disable the "permanent" zero correction factors stored in Calibration Memory. Temporary zeros are not used in Calibration mode.
3. When Calibration mode is on, the resolution available for each range and function is the same as for Average mode (refer to RANGE COMMAND CHARACTERS).

MEMORY COMMAND CHARACTERS

STORE

Commands K0 (store dc volts zero) and K1 (store ohms zero) can be used with either the 8505A or the 8506A. However, the zero value is stored in the following new fashion:

1. If Calibration mode is on (G5 response = 1), any zero value entered with the K0 or K1 command is stored directly in the Calibration Memory and retained until a new value is stored during Calibration mode on. Software calibration uses this procedure and is fully described in Appendix 7B.

2. If Calibration mode is off (G5 response = 0), any zero value entered with the K0 or K1 command is stored in a separate, temporary memory. These values do not affect the values stored in Calibration Memory. The temporary zero values are retained and applied to subsequent readings until the multimeter is powered-off or reset. The temporary zero values are all reset to 0 at power-up or reset.

3. Whenever the K0 or K1 command is used (Calibration mode on or off), a separate zero value can be stored for each range.

   a. If Calibration mode is on, the zero value is stored for the range selected without affecting the value for any other range.

   b. If Calibration mode is off, any zero value stored is applied to the existing range and all higher ranges in the same function. Therefore, separate values for each range can be entered by using K0 (or K1) sequentially for each range (from lowest to highest).

The following additional store commands are available for the 8505A or the 8506A:

1. K N G : Keep gain correction on this range. This command is used when storing calibration gain correction factors with Calibration mode on. Software Calibration (Appendix 7B) deals with this procedure in detail.

2. K N D : Keep the following six digits as the calibration date or the multimeter identification. Any value totaling 999999 or less can be entered (with Calibration mode on). Zeros are not suppressed if less than six digits are entered. The full procedure is defined in Software Calibration (Appendix 7B).

3. K 3 : Keep the error response message. This command allows the operator to specify the response for an error condition. These characters (instead of the actual reading) are then automatically returned whenever an error condition occurs. For example, the word ERROR or an obviously illegal response value (such as 1E20) can be programmed as the error response message. The desired response must be reprogrammed after a power-up or reset condition occurs. The multimeter returns 0 as the error message if no other message has been programmed. The actual error can only be identified as the first and second characters of the G1 (Get Status) response. The following rules must be followed when making the K3 entry:

   a. A maximum of any 15 characters (excepting immediate and termination characters) can be programmed following the K3 command. Spaces can be used as part of the 15 character total. Characters in excess of 15 are ignored by the multimeter and do not cause an error condition.

   b. Nulls are discarded and not stored. Nulls are not counted for the 15 character limit.

   c. Any immediate character (including termination characters) terminates and executes the string normally.

   d. The $ command is an immediate character only when used with the Bit Serial Interface (Option -06). With the IEEE-488 Interface (Option -05) or Parallel Interface (Option -07), $ is not an immediate character and can be used as part of the K3 command string.

e. The # command is an immediate character only when used with the Bit Serial Interface (Option -06) or the Parallel Interface (Option -07). With the IEEE-488 Interface (Option -05), the # command is not an immediate character and can be used as part of the K3 command string.

4. K 4 G 1 : Clear all of Calibration Memory. If it is necessary to clear all calibration factors (as in a check sum error 25 condition or prior to hardware calibration of all functions), the K4G1 command string can be used. Depending on the number of entries being cleared, several seconds may be necessary to complete this operation. Completion of this comprehensive clearing operation is verified by return of the status response.

CAUTION

If any interrupting command is sent immediately after K4 (and before G1), the comprehensive clearing operation may be interrupted prior to completion. A check sum (error 25) condition would then be set. Do not send any interrupting command (immediate characters, reset, etc.) between K4 and G1.

5. K 2 : Store previous reading as scaling factor.

RECALL

Recall DC Zero (G0)

The G0 command (recall dc zero and send on next trigger) operates in the following fashion for either the 8505A or the 8506A:

1. The multimeter can store separate dc zero values for each range. If G0 is used when dc volts function is selected, the dc zero recalled is the value for the range selected. If G0 is used when any other function is selected, the dc zero recalled is the value for the 100 mV range only.

2. The multimeter can store both non-volatile ("permanent") and temporary dc zero values. Which values are recalled depends on the state of the Calibration mode at the time G0 is used. When Calibration mode is on, the zero values recalled are the permanent values, which are stored in Calibration Memory. When Calibration mode is off, the zero values recalled are the temporary values, which are stored in a separate, temporary memory. The temporary zero values are reset to 0 when the multimeter is powered-up or reset.

Recall Status (G1)

The first two digits of the G1 response (error codes) are identified in two steps. The first step involves a user-programmed error message that is returned whenever an error condition has been generated. This message is stored in an error response buffer and serves only as a "flag" that an error exists. It does not identify the error. An error message is programmed with the K3 command, followed by any combination of up to 15 characters. For example, an obviously illegal multimeter response of 1E20 could be specified as the error message. If no such special message has been programmed, a returned "0" is used. In any case, this message alone is returned whenever an error condition has been generated and a response from the multimeter has been commanded. The error message may be returned repeatedly. This depends on the type of error condition generated (momentary or latching) and subsequent corrective actions. The following rules apply:

1. Each momentary error condition generates only one error message.

2. A latching error condition, if not corrected, generates repeated errors. Therefore, the error message is returned for each attempted reading.

For the second step, the G1 (get status) command must be sent. The first and second characters of the status response then identify the error condition by number. This two-digit error code is stored in a separate error condition buffer and is subject to the following rules:

1. A single two-digit error code can occupy the error buffer.

2. If a multiple error condition exists, only the last error to have been generated is stored in the error buffer.

Table 2A-2. Programming Instructions (8505A, 8506A) (cont)

3. The error buffer is cleared (set to 00) when either of the following actions occurs:

   a. The G1 command is sent. The error is returned in the status response, and the buffer is reset to 00. If the error still exists, a new reading must be triggered to reload the error buffer (and return the error message). If another G1 command is sent before a new reading is triggered, no error (00) is identified in the response.

   b. A valid reading is triggered. The reading is returned and the buffer is reset to 00.

The multimeter employs both momentary and latching errors. A momentary error in the buffer can be cleared by sending the G1 command or by triggering a valid reading. If the momentary error does not reoccur, further multimeter operation is not impeded. A latching error, if not corrected, does impede further multimeter operation by generating another error (and returning the error message) each time a reading is triggered. Clearing the error buffer by sending G1 does not affect this impediment. Latching errors include 12, 13, 14, 15, 19, and 24.

A momentary error condition is illustrated in the following example. Assume that 1V dc is applied to a multimeter configured for dc volts. The following sequence of commands is sent: VR0? KG1? R1? The first command (VR0?) triggers an overrange, causing the error message to be returned. The second command (KG1?) attempts to store this overrange as an offset, loads momentary error 11 into the error buffer, and returns 11 (the most recent error to be generated) in the status response. The third command (R1?) triggers and returns a valid reading and resets the error buffer to 00.

A latching error condition is encountered in the following example. Assume that the multimeter is configured for dc volts (V), but not dc current measurement (I), and 1V dc is applied to the inputs. The following sequence of commands is sent: IR1? G1? ? V? The first command (IR1?) triggers an invalid reading, loads the error buffer with latching error 19, and causes the error message to be returned. The second command (G1?) returns 19 as the first two characters of the status response and resets the error buffer to 00. The third command (?) triggers another invalid reading, loads the error buffer with 19 again, and returns the error message. The fourth command (V?) is valid. Therefore, the actual reading is returned, and the error buffer is reset to 00.

NOTE

Latching errors are enabled at all times (Calibration mode on or off) when remote operation is in use. However, latching errors can be disabled locally (with Calibration mode on). This procedure is intended for use during troubleshooting only. Do not attempt to disable latching errors at any other time.

The following additional error conditions can occupy the error buffer for either the 8505A or the 8506A:

1. 23 : The Calibration Memory is faulty or not installed.

2. 24 : Illegal module configuration.
   This error occurs at power-up or reset. It may mean that a Calibration Memory module is installed. The 8505A and 8506A do not use a separate module for calibration memory entries (calibration memory is a standard part of the Controller module). If a Calibration Memory module is installed, it must be removed. Also, error 24 may mean that the wrong ac converter configuration is installed. The 8505A uses either the -01 Option or the -09A Option (not both). The 8506A uses only the Thermal True-RMS Converter. If an illegal ac converter is installed, it must be removed. If the illegal configuration is not corrected, the error buffer is cleared (G1 sent), and a valid function is subsequently selected, the illegal module configuration does not interrupt further multimeter operation. However, if both ac converters (-01 and -09A) are installed in the 8505A, the ac volts command (VA or C) causes selection of the -09A converter only.

3. 25 : The Calibration Memory check sum is wrong.
   This error condition may occur when applying power, when storing into Calibration Memory, or when recalling a Calibration Memory entry. It may be caused by an inadvertent cycling of power when the multimeter is in the Calibration mode. Ensure that Calibration mode is off, then try re-initializing power to the multimeter. If error 25 remains, it may be necessary to first clear, and then re-enter, all correction factors, zero values, and the calibration date (or instrument identification number). If error 25 recurs during the clearing procedure or during any subsequent programming attempt, the Calibration Memory may be faulty.

4. 27 : Ohms input problem
   Error 27 can occur under any of the following circumstances:

   a. At least one ohms input connection is open.

   b. An input polarity reversal has been made in four-terminal connections.

   c. An input protection fuse is bad. For input connections at either the front panel terminals or through the rear input connector, any of the input fuses on the Front/Rear Switch PCB could be bad. Either the front or rear current/ohms fuse could also cause this error condition.

The third character of the G 1 (recall status) response is modified when used with the 8506A in an ac volts function. The third character (range codes) is then defined as follows:

0	100 mV	3	3V	6	100V
1	300 mV	4	10V	7	500V
2	1V	5	30V		

The fifth character (function codes) of the response to G1 is modified for the 8506A. Since ac current cannot be measured with the 8506A, the fifth character cannot be defined as "3". Further, if the fifth character is a "1" (ac volts) or a "5" (dc coupled ac volts), the specific ac volts function must also be identified. Since sample codes are not used in 8506A ac volts functions, the fourth character (Sample) is utilized to define whether normal mode (fourth character = 0), enhanced mode (1), or high accuracy mode (2) is selected.

Additional Recall Commands

The following additional recall commands are available with either the 8505A or the 8506A:

1. G 2 : Recall multimeter configuration and send on next trigger. This recall command is useful in determining the multimeter type and identification number, verifying the installed modules prior to a performance test or calibration, and identifying the cause of an error 24 (illegal module configuration). A 22-character response identifies the multimeter and its hardware configuration as follows:

   a. Characters 1-5: the model number (e.g. 8506A)

   b. Characters 6-8: a special number (or blank)

   c. Character 9: a colon (:)

   d. Characters 10-22: 13 characters identifying the loaded modules.

      D : DC Signal Conditioner
      F : Active Filter
      C : A/D Converter
      1 : Averaging AC Converter (Option -01)
      2 : Ohms Converter (Option -02A)
      3 : Current Converter (Option -03)
      4 : Not used (always = -)
      5 : IEEE-488 Interface (Option -05)
      6 : Bit Serial Interface (Option -06)
      7 : Parallel Interface (OPtion -07)
      8 : Isolator
      9 : True-RMS Converter (Option -09A)
      A : Thermal True-RMS Converter

Any module not installed is noted with a (-) in the response. For the 8505A, a response of DFC12----78-- would signify a standard dc volts configuration (DFC) with the Isolator (8) and options for averaging ac (1), ohms (2), and parallel interfacing (7). For the 8506A, a response of DFC--3-5--8-A would identify a standard dc volts (DFC) with the Isolator (8) and thermal true-rms volts (A) configuration with options for dc current (3), and IEEE-488 interfacing (5). Modules allowed in either instrument are defined as follows:

POSSIBLE CONFIGURATION	ALLOWED CONFIGURATION (S = standard, O = optional, N = not allowed, - = not used)	
	8505A	8506A
D	S	S
F	S	S
C	S	S
1	O (1)	N
2	O	O (2)
3	O (1)	O (2)
4	-	-
5	O (3)	O (3)
6	O (3)	O (3)
7	O (3)	9 (3)
8	S (3)	S (3)
9	O (1)	B
A	N	S

NOTES:

(1) 8505A AC Volts (VA) uses either Averaging (Option -01) or True-RMS (Option -09A) converter. 8505A AC Amps (IA) uses Current Converter (Option -03) and either ac converter. If both ac converters are installed with ac volts or ac amps selected, the True-RMS converter (Option -09A) is used.

(2) 8506A can use either the Ohms Converter (Option -01A) or the Current Converter (Option -03) — not both.

(3) 8505A and 8506A: only one interface (Option -05, -06, or -07) can be installed at one time.

2. G3: recall front/rear input selector status on next trigger. Response is as follows:

   0 (rear inputs)
   1 (front inputs)

3. G 4 : recall the calibration date (or instrument identifying) number. Response includes six digits with no leading zero suppression. If the Calibration Memory is not installed, the response is 0 0 0 0 0 0, and no error is generated.

4. G 5 : recall Calibration mode status. A returned 0 identifies Calibration mode off, and a returned 1 identifies Calibration mode on.

5. G 6 : recall Ohms zero value and send on next trigger. If G6 is sent when the Ohms function is selected, the zero value for the range selected is returned. If any other function is selected when G6 is sent, the zero value for the 10 ohm range (R0) is returned.

If any unspecified G command is attempted (such as G7), the multimeter assumes that G (recall previous reading and send on next trigger) has been sent.

Section 3
Theory of Operation

3-1. INTRODUCTION

3-2. This section describes the theory of operation for the mainframe, which includes the modules necessary for ac volts, dc volts and dc ratio measurements. Block Diagram Description gives an overview of the operation of the multimeter and an explanation of its bus structure. This description is followed by Circuit Analysis, which gives a more detailed description of the circuitry. Optional modules are described in Section 6.

3-3. BLOCK DIAGRAM DESCRIPTION

3-4. Bus Structure

3-5. The multimeter is constructed with a bus architecture similar to that of a computer. Figure 3-1 is an overall block diagram of the instrument with optional modules drawn in dashed lines. Figure 3-2 is a block diagram illustrating signal flow. A microprocessor-based Controller module controls information flow on the three buses. The Controller sets up each of the analog modules for a measurement by addressing the modules as memory locations. An unguarded digital interbus is used to connect the Controller to the front panel and to digital option modules such as the IEEE-488 Remote Interface.

3-6. The unguarded digital bus consists of the following lines:

1. Address/Control (IC)
2. Bidirectional data (ID)
3. Real time (RT)

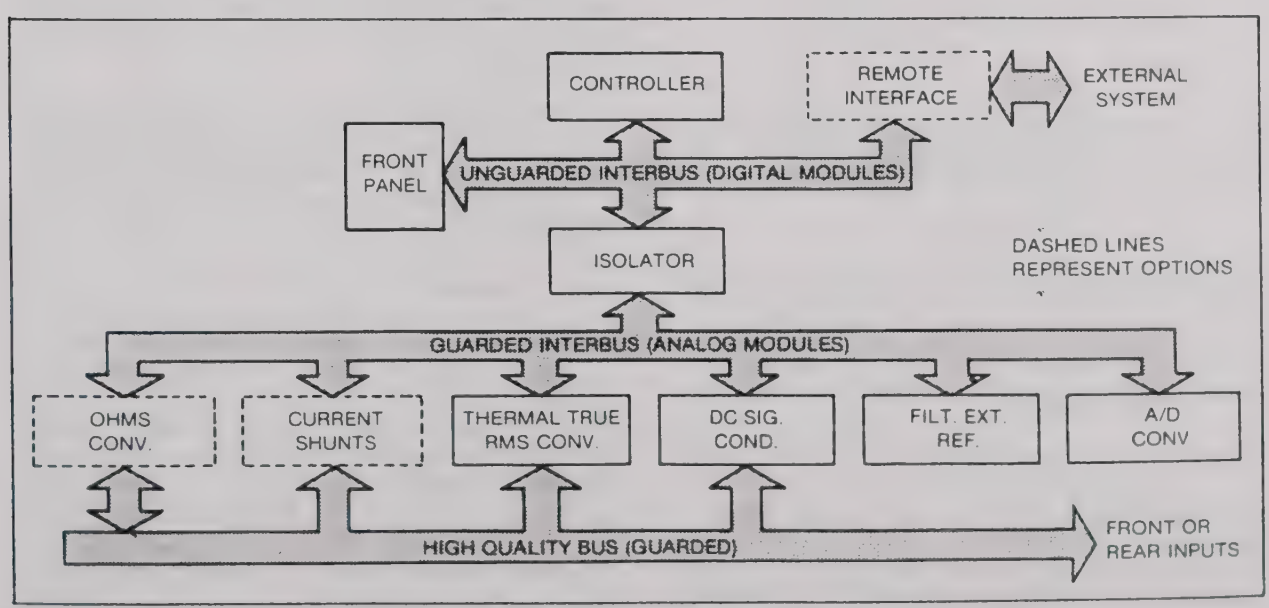


Figure 3-1. Block Diagram

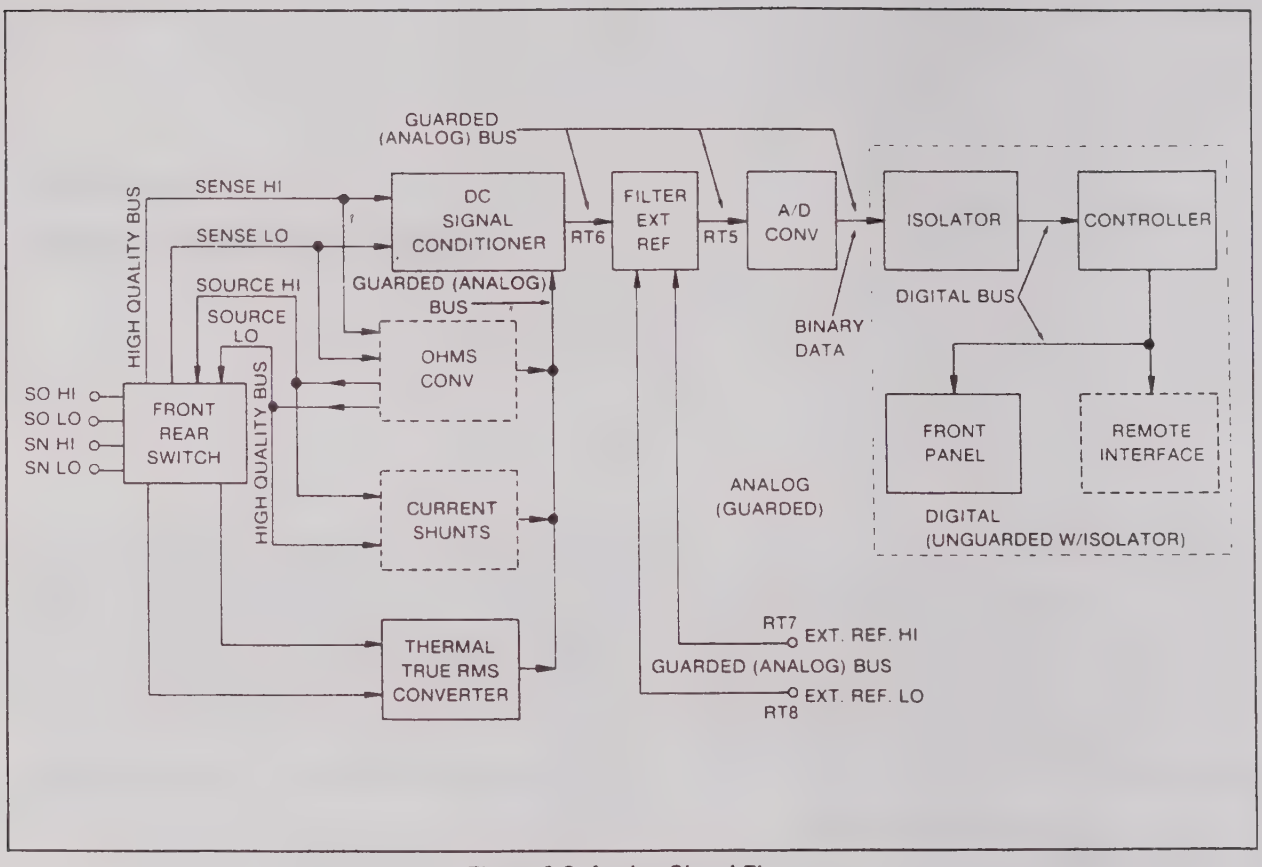


Figure 3-2. Analog Signal Flow

4. Handshake (EXTINT, ACK, INA)

5. Input/Output (SCAN ADV, EXT TRIG, FRONT/REAR SENSE)

6. Power supply

3-7. The guarded bus connects the Controller to the analog modules through the Isolator module. The guarded bus consists of the following lines:

1. Address/Control (IC)

2. Bidirectional data (ID)

3. Real time (RT)

4. Handshake (ACK)

5. Power Supply

3-8. The address, handshake, and data lines of the two buses serve the same functions. The real time and power supply lines may have differing functions. For example, the RT lines in the unguarded bus are unused except for RT5 (frequency reference). The RT lines in the guarded bus form an analog bus which carries all the conditioned and converted analog signals between the analog modules. The external reference input lines are part of the analog bus (RT7 and RT8). Logic supply lines (Vcc and Vss) are isolated from analog common when the Isolator is installed.

3-9. The high quality bus consists of lines connecting the input switch (Sense HI and LO, Source HI and LO, Guard, Ohms Guard) to the signal conditioning and converting modules. Ohms guard is only available through the rear inputs.

3-10. Controller

3-11. Under the direction of the software program, the Controller addresses and sets up each of the modules necessary to perform a function. Two types of addresses are used: direct and indirect. An indirect address requires a previous direct address to set up the indirect address response logic. Data transfers are accomplished with a handshake between the address (IC) lines and the acknowledge (ACK) line. When the controller addresses a module, it places data on the data (ID) lines or receives data from the addressed module. The addressed module must respond with an ACK signal signifying that it is receiving or sending data.

3-12. The Controller directs each step of sample processing. The A/D Converter is first directed to take the selected number of samples-per-reading (2 exponent 0 through 2 exponent 17). Using the arithmetic capability of the microprocessor, Controller software then sums all samples and divides by the number of samples to compute the average sample value. This digital filtering reduces noise. The average sample value is then scaled to correct for the integer gain and attenuation of analog modules used in taking the reading, and then corrected by any stored calibration factors for those analog modules. If the multimeter is in Zero mode (V DC and OHMS functions only), the value is also corrected by the temporary zero correction value. The averaged, corrected reading is then scaled by either the Scaling mode or External Reference mode factor, and finally offset by the Offset mode value. The result of these processes is the value of the reading. Peak and Limit modes are applied to this reading. The resulting number (or indication in Limits mode) is made available to an optional remote interface either in binary two's complement form, or, after further processing, in ASCII code. This number (or indication) is further processed by the controller for application to the front panel display in a seven-segment LED format. Each sample (prior to any correction or processing) may also be transmitted directly across the remote interface by using the High Speed mode.

3-13. The software program consists of two parallel processes. A background process (Figure 3-3) is responsible for interrupt driven activities such as updating the display digits and directing the A/D converter in taking a sample. The foreground process (Figure 3-4) is responsible for the measurement cycle including accumulating data from the background process and performing required calculations.

3-14. The controller is structured around the Intel 8080 microprocessor. Figure 3-5 is a block diagram of the controller module. Hardware control functions have been minimized by software design. Sequences of events are timed from two sources. Basic operations of the microprocessor are run from a 1.7 MHz clock. The other source is generated by shaped line frequency pulses, which are applied to a phase-locked loop. The phase-locked loop multiplies the line frequency by eight. This signal is used to generate mark interrupts which time the background process.

3-15. Memory for the multimeter consists of two ROMs for software, one RAM for variables, and one EEROM for calibration memory. Data lines (DB0-DB7) are used for bidirectional data flow. Address lines (A0-A15) determine the source or destination for data and instructions. Modules in the multimeter system are memory mapped and are accessed through normal memory reference instructions.

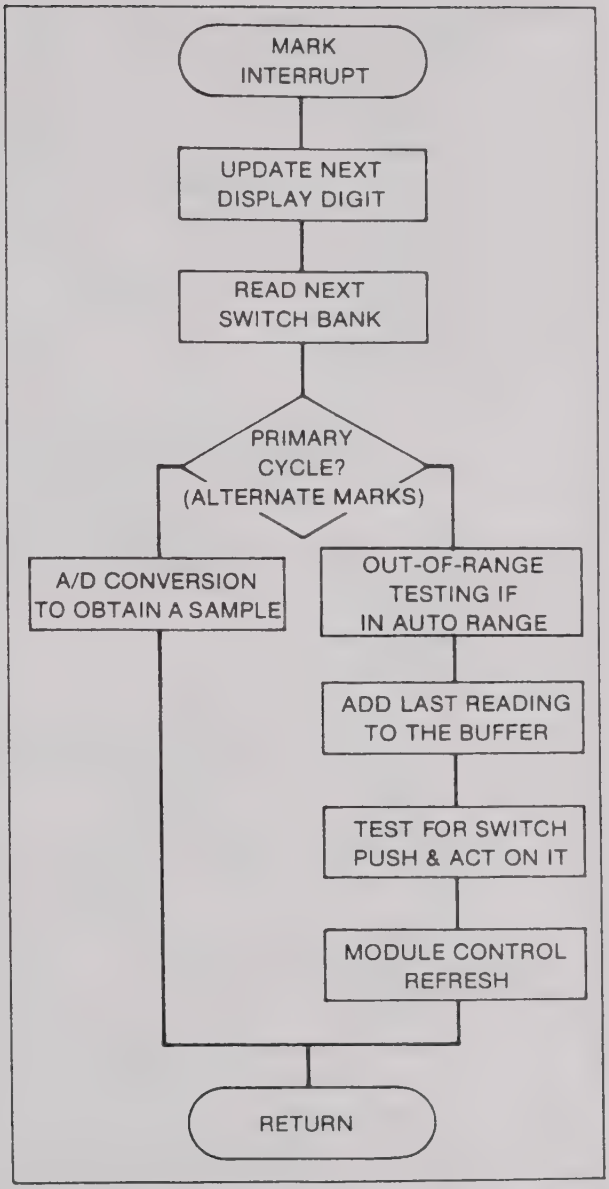

MARK INTERRUPT
UPDATE NEXT DISPLAY DIGIT
READ NEXT SWITCH BANK
PRIMARY CYCLE? (ALTERNATE MARKS)
A/D CONVERSION TO OBTAIN A SAMPLE
OUT-OF-RANGE TESTING IF IN AUTO RANGE
ADD LAST READING TO THE BUFFER
TEST FOR SWITCH PUSH & ACT ON IT
MODULE CONTROL REFRESH
RETURN

Figure 3-3. Background Software Process

3-16. Interrupts are used to divert the microprocessor from the main program to service other routines. Interrupts are synchronized to an appropriate time in the microprocessor cycle through interrupt control, where assigned priorities vector module identity data onto the data bus. Module identity data words direct the microprocessor to the memory location containing the next instruction. Two interrupts are internally generated: ACKINT and MARKINT (priorities one and six respectively). ACKINT is generated when an acknowledge signal is not returned. MARKINT is used to synchronize A/D samples and display updates to the line frequency.

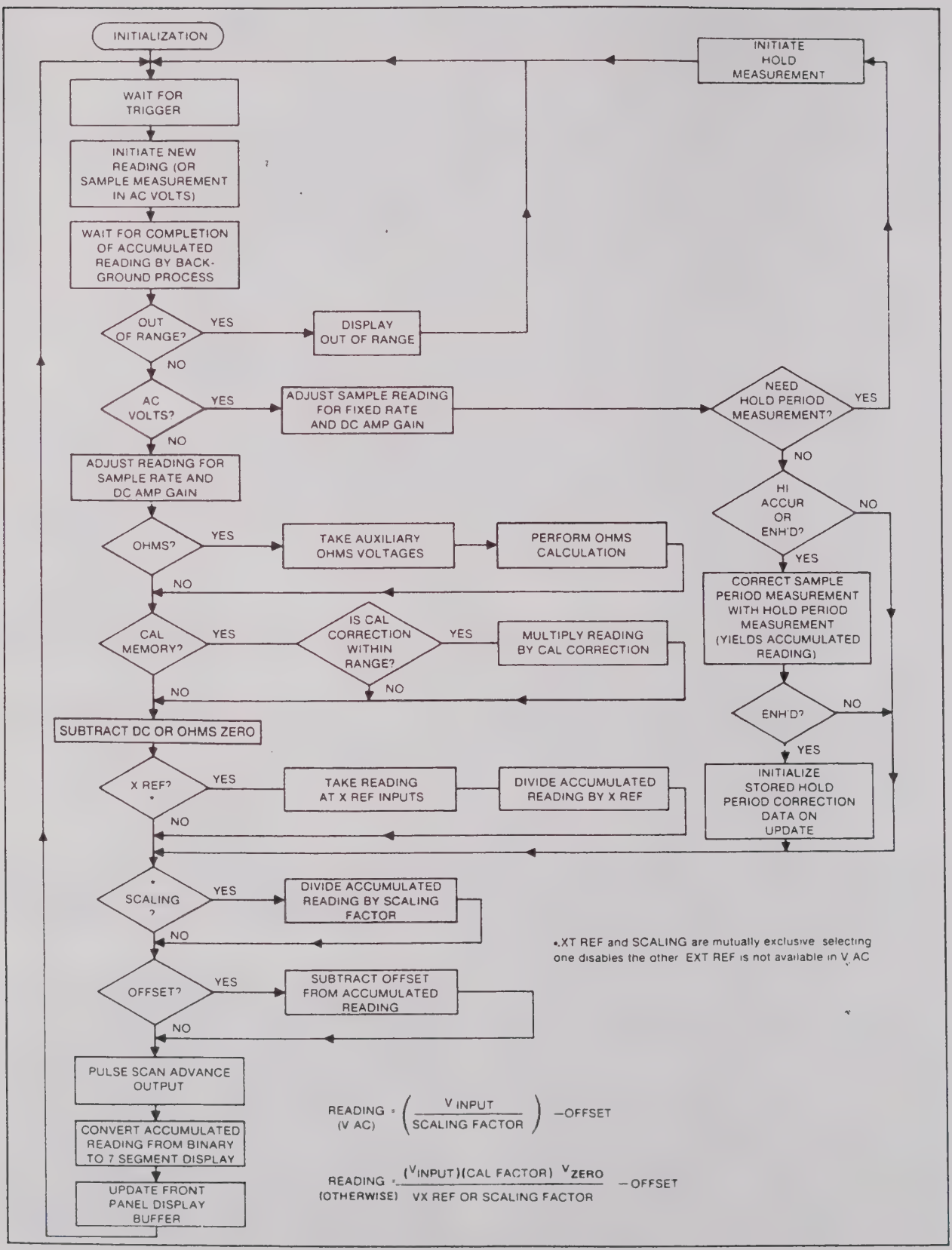


Figure 3-4. Foreground Software Process

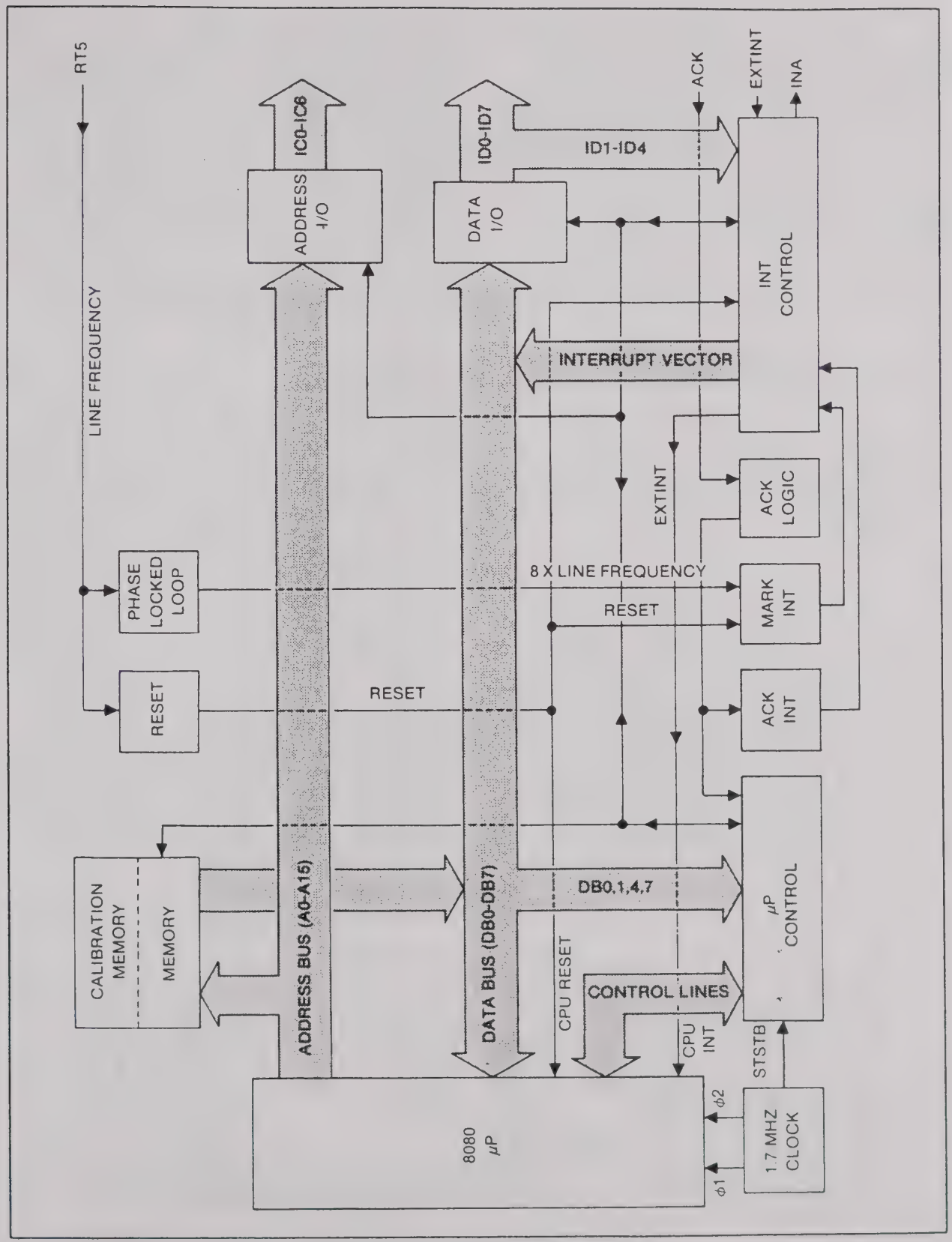


Figure 3-5. Controller Block Diagram

3-17. An interrupt may be externally requested by pulling the EXTINT line low. When the microprocessor is ready to accept the interrupt, the interrupt acknowledge (INA) signal is generated. The requesting module must respond with an ACK and a data bit (on ID1-ID3) which is used as a priority vector by interrupt control.

3-18. Software or hardware resets may occur. Software resets result from front panel requests or remote requests. Hardware resets are generated from the reset logic by monitoring line frequency on RT5. On power-up, or for line disturbances, the reset logic initializes the microprocessor and other logic. At power down, the reset signal prevents erroneous operation.

3-19. The control logic can be divided into two areas: control of the microprocessor and control of the external logic. The microprocessor control logic is used when the microprocessor enters and exits wait states. The external control logic is responsible for latching status information from the microprocessor at the beginning of each instruction cycle. The status information controls and synchronizes the activities of the external logic.

3-20. Front Panel

3-21. The front panel serves as an interface between the operator and the controller. The display is multiplexed by the controller by means of addressing the front panel for each digit. One direct address, two indirect addresses, and the accompanying data determine which digit or annunciator will light and which segments will light. An indirect address requires a previous, valid direct address to set up the indirect response. Another direct address enables the switch matrix to be read to determine if any function changes are desired. The cycle of updating each digit and annunciator and reading the switch matrix requires approximately 28 ms and is continuous. Input terminals, J1-J5, are physically located on the front panel but have no electrical interaction with the front panel.

3-22. DC Signal Conditioner

3-23. DC signals from the input terminals (direct in V DC), from the Thermal True RMS Converter (V AC), or from optional signal conditioners (OHMS or A DC) are routed through the DC Signal Conditioner to be brought within the range of the A/D Converter (±20V). Figure 3-6 is a block diagram of the DC Signal Conditioner. Gain or attenuation factors are selected by the microprocessor addressing the module. Data from the data bus is latched into the control circuitry and used to select relays in the attenuator and switches in the amplifier feedback circuit. The combination of the attenuator and feedback-controlled amplifier give gain factors of 1, 10, or 100 and attenuation factors of 1 or 64.

3-24. Active Filter

3-25. The purpose of the Active Filter module is to multiplex dc signals to the A/D Converter and to switch analog filters into the signal path. Figure 3-7 is a block diagram of the Filter/External Reference module. Five filter modes may be selected from the front panel. For external reference measurements, the signal conditioner input, the External Reference HI input and the External Reference LO input are multiplexed to the A/D Converter. Samples are taken of each input and arithmetically manipulated by the Controller to arrive at a reading.

3-26. Fast R^2 A/D Converter

3-27. The Fast R^2 A/D Converter employs Fluke's patented recirculating remainder (R^2) technique for converting a dc input signal into a binary, bit-serial data stream. The R^2 technique has been modified for microprocessor control. Obtaining a sample is a five-step process. Each step consists of a decision period of five decisions and a subtraction period. Set-up of the converter, decisions, and reset are initialized by the Controller addressing the A/D Converter. Figure 3-8 is a block diagram of the R^2 A/D Converter.

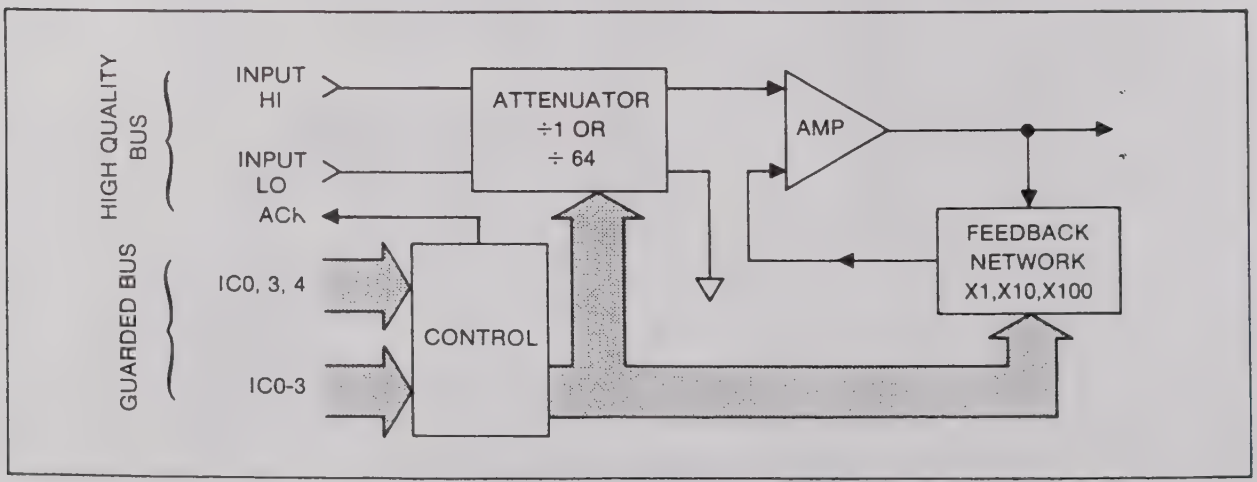


Figure 3-6. DC Signal Conditioner Block Diagram

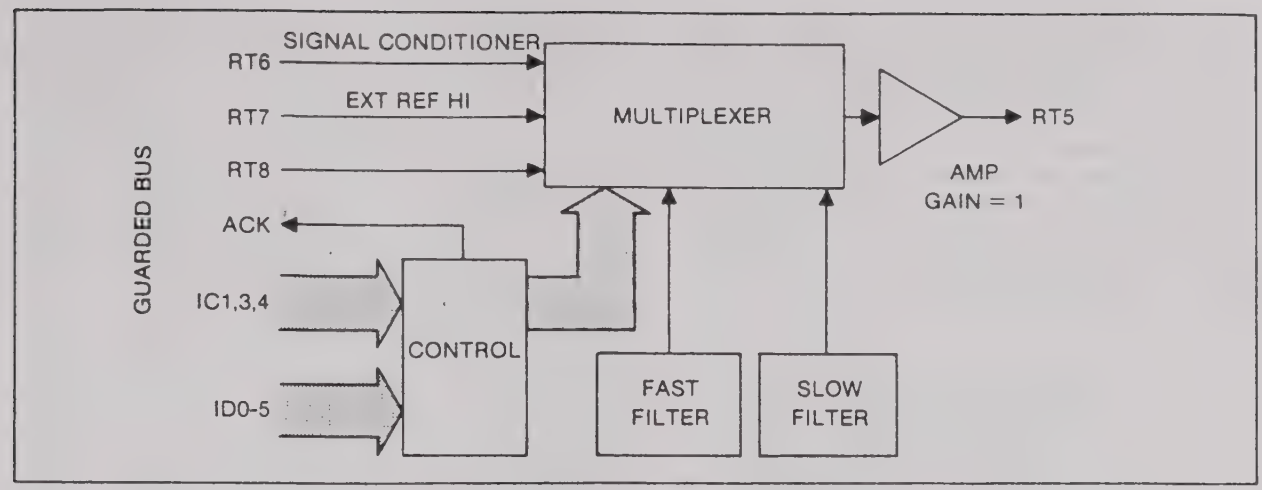


Figure 3-7. Active Filter Block Diagram

3-28. During the first step, the input signal is applied to the Summing Node. The polarity of the input is detected and the resulting bit of information is transmitted to the Controller. On the basis of the returned polarity, the A/D module selects which reference polarity is required: positive for negative inputs, negative for positive inputs. The first of five precision currents is switched into the Summing Node and a polarity bit returned. If the polarity is changed, the first current is switched off. If the polarity is not changed, the current is left on. Then the next current is switched into the Summing Node and another polarity bit returned. Another decision is made and so on until all five currents have been switched into the Summing Node and five decisions have been made. This completes the first decision period. The five precision currents are related by powers of two. The fifth current has a resolution of thirty two.

3-29. Following the decision period is a subtraction period. Feedback through the Remainder Storage nulls

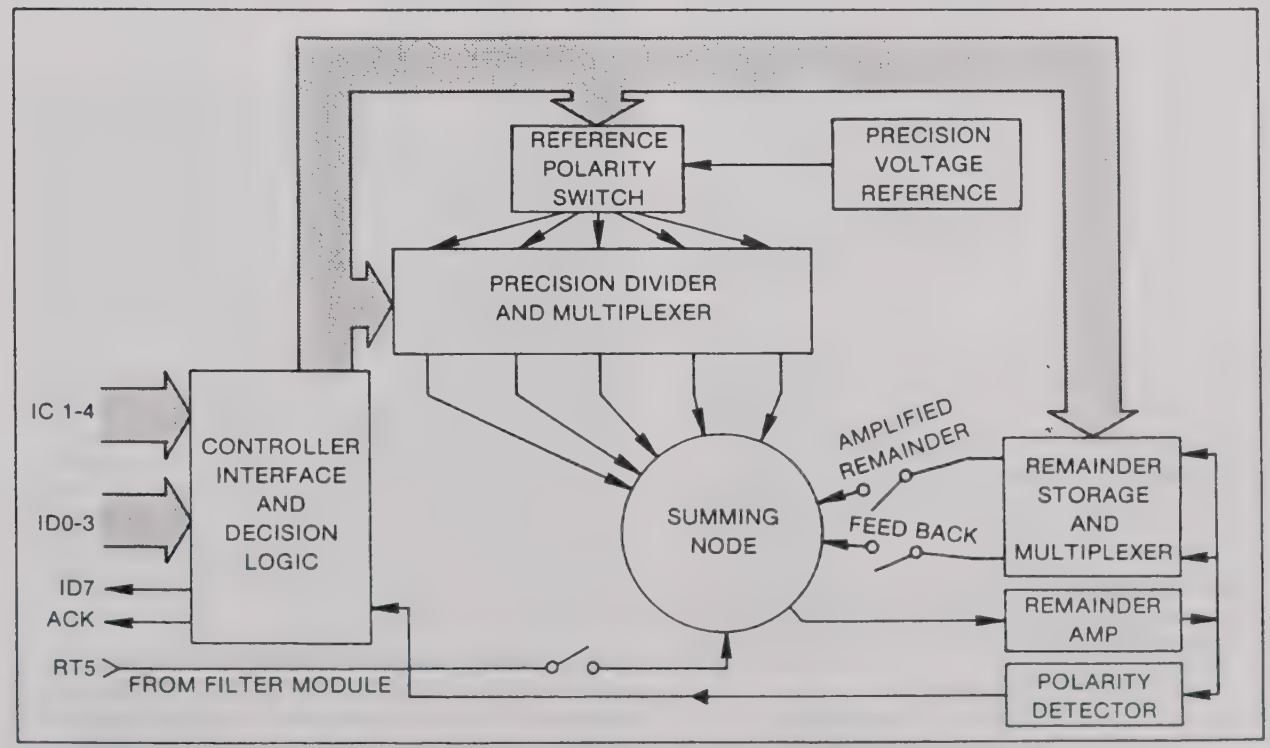


Figure 3-8. R^2 A/D Converter Block Diagram

whatever remainder was left after the five currents have been switched into the Summing Node. The remainder is amplified by 16 in the Remainder Amp and is stored on a capacitor in Remainder Storage. This completes the first step. The input is now switched out of the Summing Node and the amplified remainder switched in for the next step. There are two remainder channels in Remainder Storage and they are alternated in the four subsequent steps. Since the fifth current has a resolution of thirty two and the Remainder Amp has a gain of 16, the first bit of a step has the same significance as the last bit of the previous step.

3-30. Of the five steps required to complete a sample, the first uses the input signal for decision and subtraction periods. The four subsequent steps alternate remainder channels to use the amplified remainder of the preceding step for decision and subtraction periods. Polarity bits returned at each decision are accumulated by the Controller and assembled into a 24-bit word describing the polarity and magnitude of the input.

3-31. Thermal True RMS Converter

3-32. This description is divided into two parts. The first is a theoretical description of the rms converter. The second is the operation of the rms converter within the multimeter.

3-33. THEORETICAL DESCRIPTION

3-34. Previously AC/DC transfer measurements were made by sequentially applying an unknown ac voltage and a variable dc voltage to an rms sensor until the outputs were equal. The rms voltage was then assumed to be equal to the value of the dc voltage applied at the time the two inputs were equal. The Thermal True RMS Converter module differs in that it uses the dc equivalent value of the rms sensor's first output to serve as the first approximation for the comparison. Therefore, if a computation capability is available, and the transfer curve of the sensor is reasonably smooth, the first iteration is the only one necessary to obtain a high accuracy measurement.

3-35. Figure 3-9 shows an ideal curve where the rms input (X) equals the dc output (Y), an example of an actual curve, and the positions on the curves for two separate readings. X1 represents the value of the original unknown rms input and Y1 represents the dc value of the sensor output. The difference, or error, between the two values is represented by E1. A second dc voltage (X2) equal to Y1 is applied to the sensor which produces an output Y2. From these it can be seen that: Y1=X1+E1, Y2=X2+E2, and X2=Y1. Substituting these values into the formula 2(Y1)-(Y2) the rms value of the original input can be computed from the following derived formula.

$$
\begin{aligned}
X\ (\text{computed}) &= 2(Y1)-(Y2) \\
&= 2(X1+E1)-(X2+E2) \\
&= 2(X1+E1)-(X1+E1+E2) \\
&= X1+(E1-E2)
\end{aligned}
$$

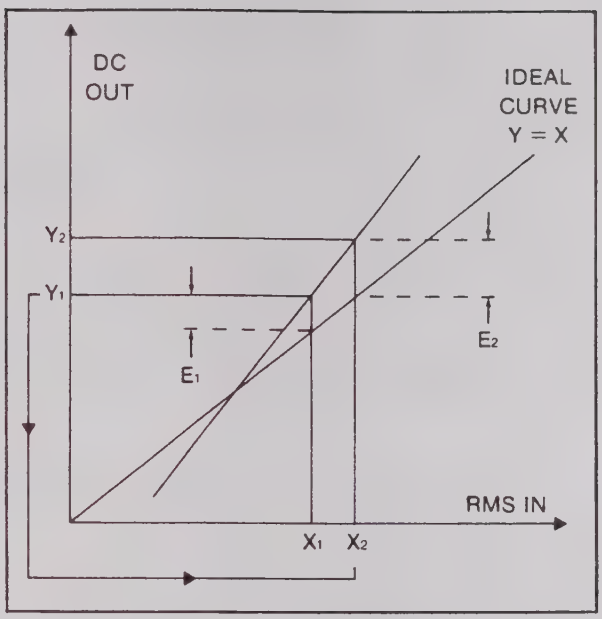


Figure 3-9. Ideal Curve

3-36. Solution of the example formula shows that by doubling the first sensor output and subtracting the second sensor output, the original input can be computed to an accuracy determined by how much the error changes between the two readings. The closer together the two points and the smoother the error curve, the lower the resultant error (E1-E2).

3-37. SYSTEM OPERATION

3-38. Figure 3-10 is a block diagram of the Thermal True RMS Converter in relation to the multimeter when used in the thermal true rms function. The unknown ac signal is applied through the input attenuators, ranging amplifier, and sensor switching circuits to the Fluke thermal sensor. The sensor output is simultaneously measured by the multimeter and routed through the sensor switching circuits for storage by the sample/hold circuit. The measured value is doubled and the result stored in memory (part of the controller). The controller module then commands the logic control circuit to alter the sensor switching circuits to open the path from the ranging amplifier output and to close the path from the sample/hold output (the stored sensor measurement) to the thermal sensor input. The sensor output is then measured again by the multimeter and the result subtracted from the stored value (twice the first measurement). The difference is displayed as the rms value of the original input signal.

3-39. The unknown input signal must be within the dynamic range of the measuring circuit to use this technique. The input attenuator circuit and ranging amplifier, as directed by the controller (system software) through the logic circuit, bring the input signal within the

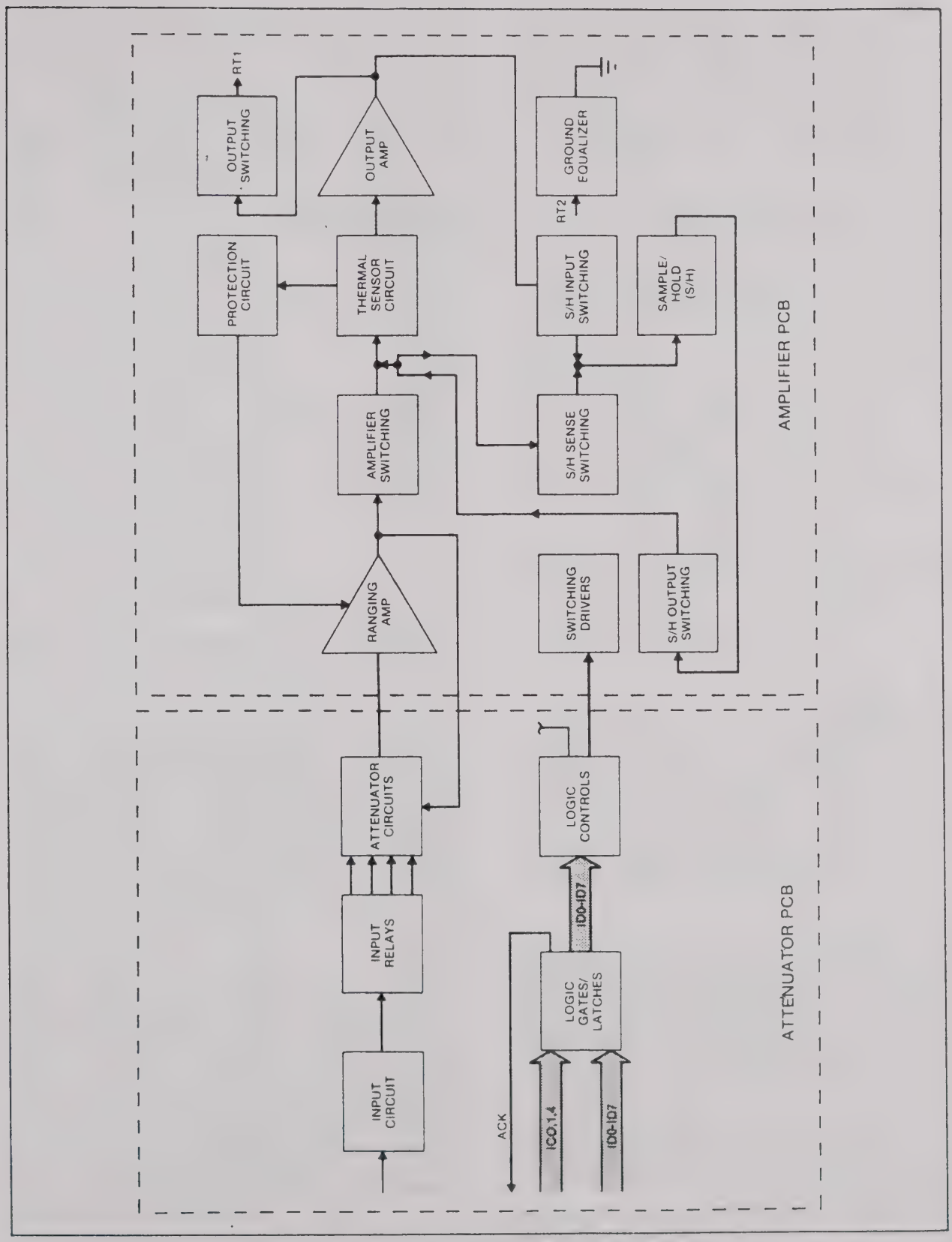


Figure 3-10. Thermal True RMS Functional Block Diagram

range required. AC accuracy limitations at full scale for this technique are primarily due to the flatness of the input attenuator and the ranging amplifier. At one tenth of full scale the limitation is 1/f noise in the sensor. DC accuracy limitations are primarily due to the input drift of the ranging amplifier. The 6-second response time is determined by the thermal sensor time constants and the associated circuitry.

3-40. Front/Rear Switch Assembly

3-41. Analog inputs are applied either at front panel terminals or through a rear panel connector. The Front/Rear Switch Assembly is controlled by the Rear Input Selector on the front panel. When disengaged (out), this selector routes front panel INPUT HI and LO, SOURCE HI and LO, and GUARD connections to the multimeter analog bus. The front panel Ohms Selector and Guard Selector influence only the front panel inputs: these two selectors have no effect on the rear inputs. When engaged (in), the Rear Input Selector routes INPUT HI and LO, SOURCE HI and LO, GUARD, and OHMS GUARD from the rear input connector to the analog bus. External Reference HI and LO inputs are also applied through the rear input connector but are not switched. Separate fuse protection is used for front panel (SOURCE HI) and rear (SOURCE HI) inputs. Front/Rear Switch position is sensed by the Controller via a photocoupler. This arrangement allows for interrogation of the Front/Rear Switch position through a remote interface while maintaining guard integrity.

3-42. CIRCUIT ANALYSIS

3-43. Introduction

3-44. Detailed circuit description of each module in the standard mainframe is presented in the following paragraphs. Optional modules are covered in Section 6. The block diagram description should be read first to get an understanding of the overall functioning of the instrument. Schematic diagrams are located in Section 8 (Section 6 for optional modules). Table 3-1 is a list of mnemonic definitions used in the Controller schematic.

3-45. Controller

3-46. TIMING

3-47. Refer to Figure 3-11. Timing for the microprocessor is derived from a 12V, two-phase clock (01 and 02). The two-phase clock is generated by clock generator U14, which is designed to meet the timing requirements of the microprocessor. The clock generator also uses internal logic and a SYNC pulse from the microprocessor to generate an STSTB signal (which clocks microprocessor status information). The period of the 01 clock (585 ns) governs the duration of a machine cycle; there are three to five states in a machine cycle and one to five machine cycles in an instruction cycle.

3-48. Shaped line frequency pulses are applied to phase-locked loop U26 which runs at eight times the line frequency (480 Hz for 60 Hz line, 400 Hz for 50 Hz line).

Table 3-1. Mnemonics

A0-A15	Address bus on controller
ACK	Acknowledge signal from module
ACKINT	Interrupt generated when module does not respond
CPUINT	Interrupt signal for μP
CPUREADY	Ready signal for μP
CPURESET	Reset signal
D0-D7	Data bus on controller
DBIN	Data bus input signal (from μP)
DLDACK	Delayed version of ACK
EXTCOM	Module communication signal
EXTINT	Interrupt from module
FLINE	Shaped line frequency signal
8xFLINE	8 times line frequency
FRONT/REAR	Front or rear input signal
IC0-IC7	Module address/control bus
ICENABLE	Enable module address signal
ID0-ID7	Module data bus
INA	Interrupt acknowledge signal in response to EXTINT
INP	I/O status signal
INTA	Interrupt acknowledge status signal
INTCLR	Clear interrupt signal
LINEREF	Line reference signal, bus input on RT5
MARKINT	Interrupt to synchronize to line frequency
Ø1	One phase of μP clock
Ø2	Other phase of μP clock
OUT	I/O status signal
READY	Signal to generate CPUREADY
RESET	Reset signal
RUN	Exit wait state signal
SCANADV	Scan advance signal, A/D conversion complete
STOP	Enter wait state signal
STSTB	Clock signal to latch μP status
SYNC	Signal from μP, used to generate STSTB
SYNCDEXTINT	Synchronized interrupt from module
Vbb	-5V supply
Vcc	+5V supply
Vdd	+12V supply
Vgg	-12V supply
Vss	Logic common
WAIT	μP in wait state signal
WR	Write data signal from μP

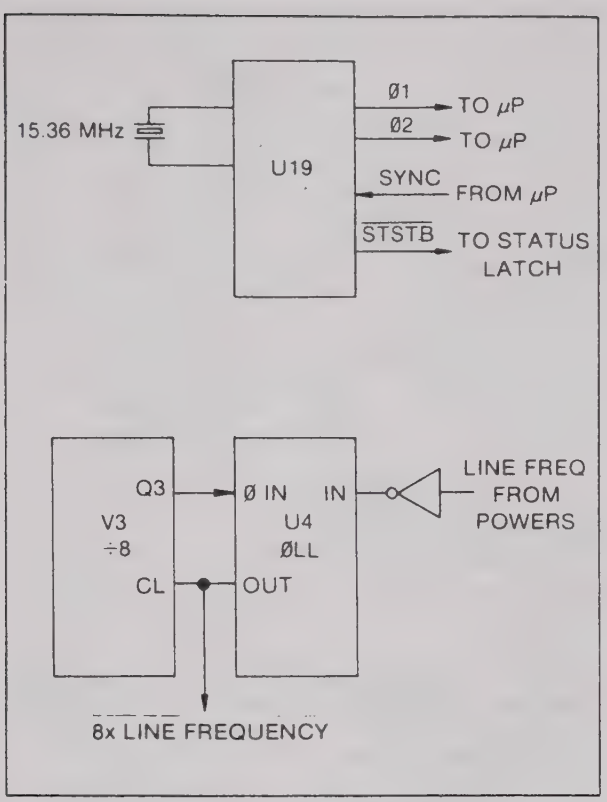


Figure 3-11. Timing Circuits

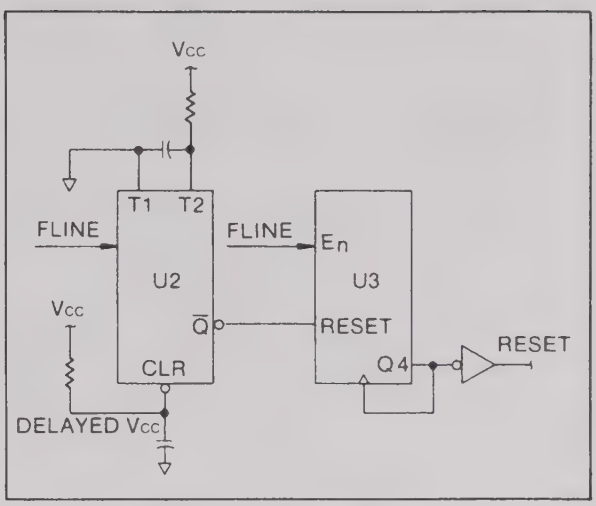


Figure 3-12. Reset Logic

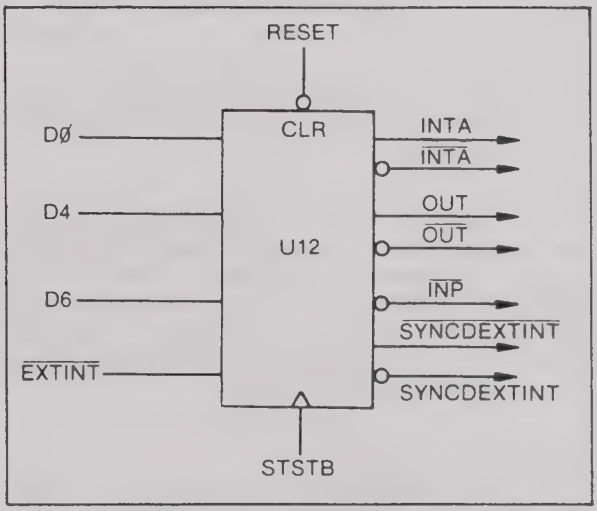


Figure 3-13. Status Latch

3-49. ADDRESS AND DATA BUSES

3-50. ROM locations are decoded from A14 and A13, as chip selects and from A0 through A12. RAM locations are decoded from A14 and A11, as chip selects, and from A0 through A10. External modules are selected by setting A15 high. Inverted forms of A8 through A14 are sent out as IC0 through IC6 on the unguarded bus. The data bus lines (D0 through D7) are connected directly to internal memory and through tristate buffers to the external data bus (ID0 through ID7).

3-51. RESET

3-52. Refer to Figure 3-12. Shaped line frequency pulses are applied to U2 and U3, providing a hardware reset on power down, power up, or for missing line cycle pulses. In any of these three reset conditions, retriggerable one shot U2 (T=40 ms) generates a reset pulse for up counter U3. After the reset to U3 is removed (delayed Vcc high or a line frequency pulse), U3 must be clocked by eight line frequency pulses to raise Q4 high and remove the reset signal. The reset pulse is held for eight line cycles to allow time for the power supplies and microprocessor oscillator to stabilize.

3-53. STATUS LATCH

3-54. Refer to Figure 3-13. During the first state of every machine cycle, the microprocessor sends out a status word on the data bus. This status word contains the information for external logic to synchronize with microprocessor activity (e.g., memory read, interrupt acknowledge). Clock signal STSTB (from U19) clocks this information into quad D-type flip-flop U12 for use during the machine cycle. External interrupts are also latched into the status latch for synchronization to the microprocessor.

3-55. WAIT LOGIC

3-56. Refer to Figure 3-14. When the microprocessor addresses an external module, the wait state logic forces the microprocessor to enter a wait state and allow the module time to respond. When the microprocessor acknowledges an interrupt, the wait state is similarly forced to allow time for the interrupt vector to be generated. A wait state is entered when a rising edge on STOP (the clock input U1) sets READY low. Clock

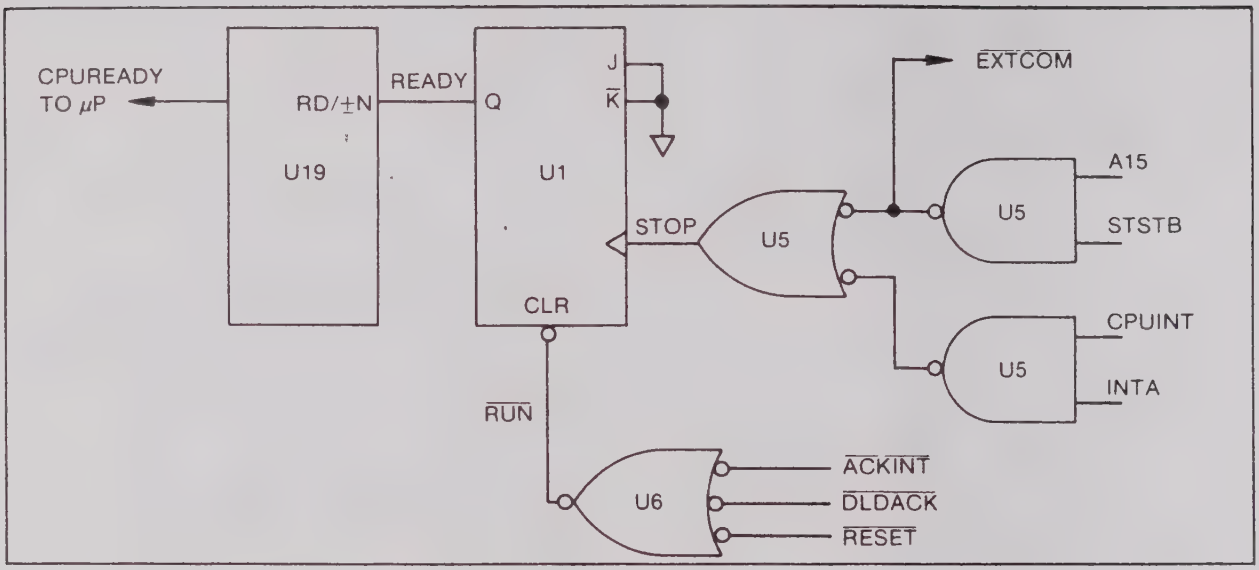


Figure 3-14. Wait Logic

generator U19 then synchronizes READY to the timing requirements of the microprocessor and pulls CPUREADY low.

3-57. To exit the wait state, RUN (the clear input to U1) must be pulled low. Two events cause this to happen. ACKINT is asserted by the interrupt circuitry if the addressed module does not return an ACK in a specific time period. Alternately, DLDACK is asserted. DLDACK is asserted by a module returning an ACK or by response to a MARKINT.

3-58. ACK LOGIC

3-59. Refer to Figure 3-15. When a module is addressed by the controller or is enabled for interrupt identification by INA, it must return an ACK (high) to complete the handshake. ACK is delayed about 1.6 us to produce DLDACK. DLDACK is also generated in a MARKINT interrupt response cycle.

3-60. INTERRUPTS

3-61. Two possible internal interrupts (MARKINT and ACKINT) and three possible external interrupts (EXTINT) are able to drive CPUINT high and interrupt the microprocessor. The microprocessor samples the interrupt line at the end of each machine cycle. If an interrupt exists, the microprocessor asserts INTA in the status word of the next instruction fetch machine cycle. External logic is thereby enabled to place an interrupt vector (and not the next instruction) on the data bus. Refer to Figure 3-16.

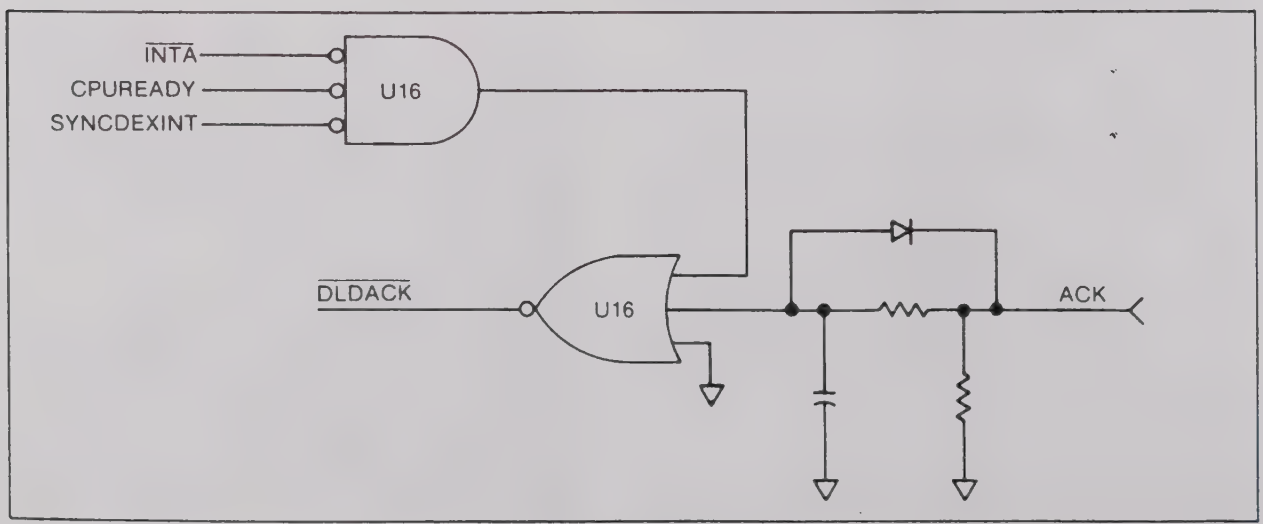


Figure 3-15. ACK Logic

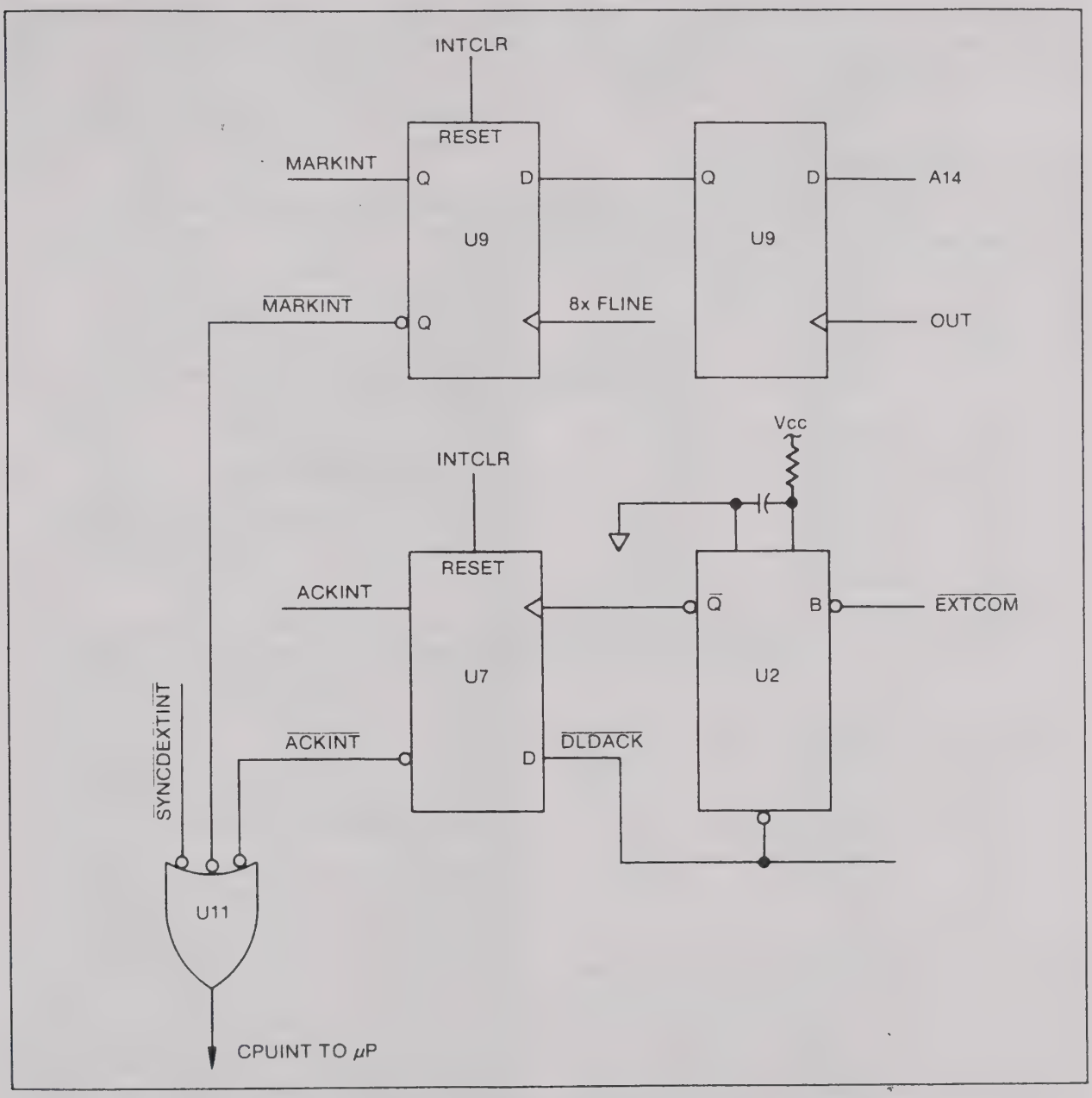


Figure 3-16. Interrupt Generation Logic

3-62. Internal interrupts are ACKINT and MARKINT (Figure 3-16). The ACKINT logic consists of a retriggerable one-shot (U2) and a D-type flip-flop (U7). EXTCOM (A15 and STSTB) triggers U2. If DLDACK does not occur in the time constant of U2, U2 clocks U7 and asserts ACKINT. This action takes the microprocessor out of the wait state.

3-63. The MARKINT logic consists of two D-type flip-flops. The first (U9-1) can be written to enable or disable MARKINTS. The second (U9-12) is clocked by the eight times line frequency signal from the phase-locked loop.

3-64. Interrupts are prioritized by U-21 (refer to the Controller schematic in Section 8). ACKINT interrupts have the highest priority, and MARKINT interrupts have the lowest priority. External modules must drive ID1, 2, or 3 high in response to INA, to generate the correct vector for that module.

3-65. Front Panel

3-66. Refer to Figure 3-17. Annunciator segment data is clocked into register one by the direct address, IC0, 1, 5 high. Data output from the switch matrix is also a direct

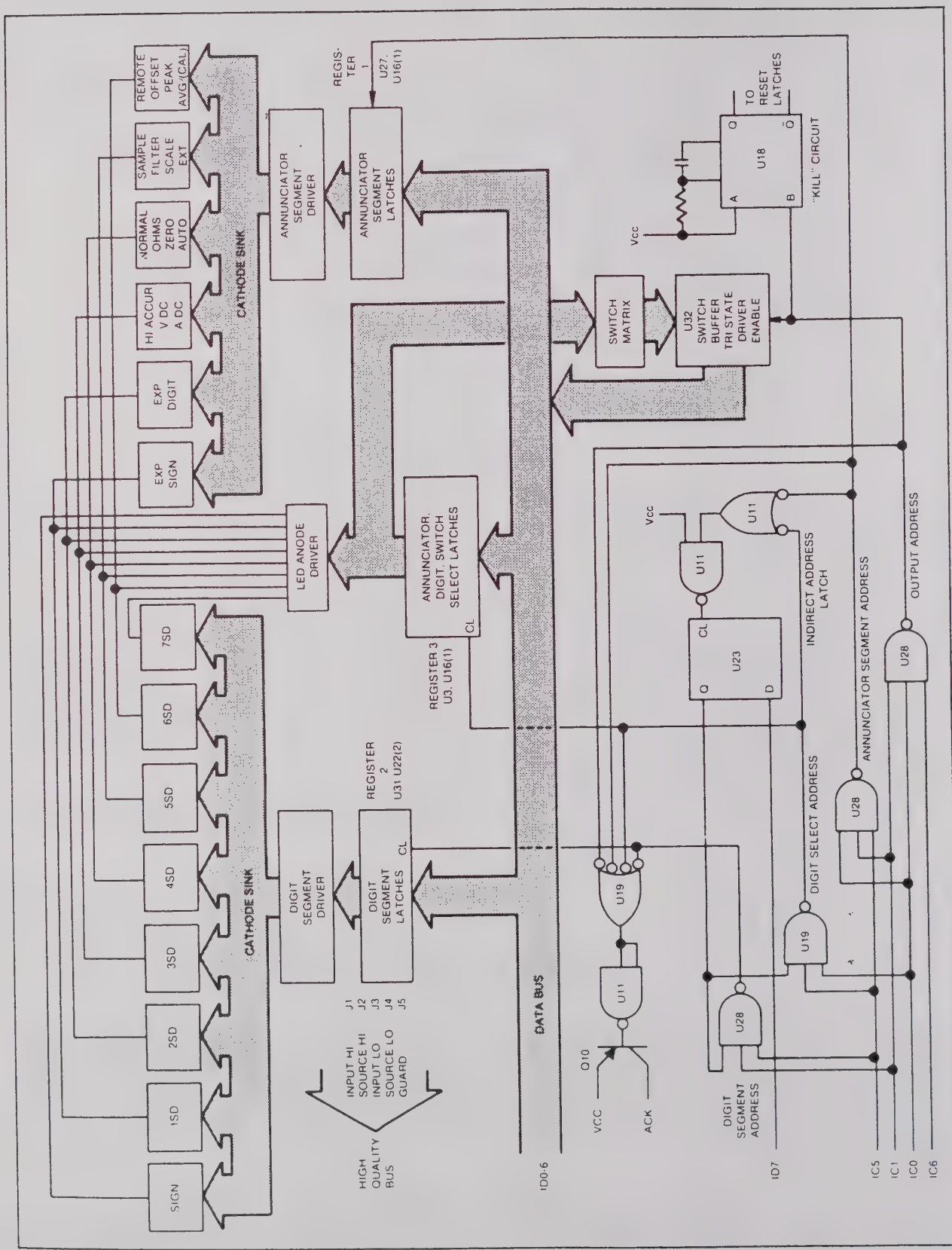


Figure 3-17. Front Panel

address-IC0, 1, 6, high. For either direct address, the condition of ID7 (high for disable) is latched into U23 to enable an indirect address. Digit segment address-IC1, 5 high, and digit-annunciator select address-IC0, 5 are both indirect addresses. Data is clocked into the registers upon termination of the address. An update sequence is as follows:

1. Register 1 is addressed with all data lines low to blank the annunciator display and enable indirect addressing.

2. Register 2 is addressed indirectly with data lines low to blank the digit display.

3. Register 3 is addressed indirectly with all data lines high to turn off all LEDs, disable the switch matrix, and disable indirect addressing.

4. Register 1 is addressed with ID7 low to enable indirect addressing and with either annunciator segment data or digit 7SD data on ID0-6. The data is latched and applied to the annunciator LEDs (or to digit 7SD).

5. Register 2 is addressed with digit segment data on ID0-7 (U23 is not clocked by this address so ID7 may be high without disabling indirect addressing). The data is latched and applied to the digit LEDs.

6. Register 3 is addressed with ID7 high (disable indirect addressing) and one of the data lines, ID0-6 low to enable one digit LED and one annunciator LED. One bank of the switch matrix is also enabled.

7. The output buffer is addressed enabling the data from the previously enabled switch bank to be placed on the data bus. One or more lines being low indicates a change is desired. This address also keeps the kill circuit charged.

3-67. The seven steps just outlined are required for one digit-annunciator-switch bank update. The process is repeated seven times for a complete update. The kill circuit is used to blank the display if the Controller discontinues addressing the front panel.

3-68. DC Signal Conditioner

3-69. Relays K1 and K2 control the input to the DC Signal Conditioner and the attenuation of the input (Figure 3-18). If both relays are energized, the input is from the Volt/Ohm input terminals with no attenuation. If just K2 is energized, the input is from RT1 with no attenuation. CR3, CR4, CR11 and CR12 provide overvoltage protection.

3-70. A precision op amp (U3) and gain boosting stage (U2) buffers the input of the instrument. FET switches (Q14, Q15, Q16) control the gain of the buffer. An input and output voltage swing of ± 20V is achieved through bootstrapping; Q22 and Q23 provide a bootstrap for U4, and U5 and U6 provides a bootstrap for U3. U4 provides guard voltage and input bias current compensation.

3-71. The DC Signal Conditioner is addressed by IC0, 3, 4 high and IC1, 2 low. Data on ID0-3 is latched up and decoded to determine which switches and relays will be energized. Latching relays are used to eliminate thermal changes in the relays between on and off states. RC coupling between the decoder and the relay driver provide pulses, which activate the appropriate coil of the relay long enough to ensure proper operation of the relay, on each level shift of the decoded signal.

3-72. Filter/External Reference

3-73. All inputs to the A/D Converter are routed through the Filter/External Reference module. Refer to Figure 3-19. External measurements are made by multiplexing the three filter module inputs to the A/D Converter. Q18, Q19, and Q20 switch the signal conditioner input, the external reference LO input, and the external reference HI input respectively. Data controlling the switches is latched into U1 upon termination of the address (IC1, 3, 4 high).

3-74. Three-pole, active Bessel filters (U3 and U4) have different setting times and cut-off points. Either filter may be selected from the front input panel for application to the signal conditioner input. Bypass is automatically selected for external reference inputs and may be selected for signal conditioner inputs. The combination of Q32, Q25, Q23, Q24, or Q21, Q22 is turned on to select a filter mode.

3-75. A dual, super-beta transistor in a differential configuration (Q27) drives U5. A current source (Q26) and sink (Q30) bias Q27. Enough current is drawn through R19 by Q26 to bootstrap the input amplifier, Q27, 5V above the output. Gain of the amplifier is set at one by the combination of R21 and the input resistors. The external reference inputs have additional series resistors located on the Front/Rear Input Assembly.

3-76. Fast R^2 A/D Converter

3-77. The Fast R^2 A/D Converter may be separated for analysis into two component groups: analog and digital. Analog circuitry is responsible for producing a voltage reference, for summations, and for remainder amplification and storage. Digital circuitry interfaces the analog circuitry to the Contoller and is responsible for reference selection, decision in the summation process, remainder channel control, and autozeroing. Since functions within the A/D Converter are either directly controlled by the Controller module via the data bus or are clocked through their operations by the Controller

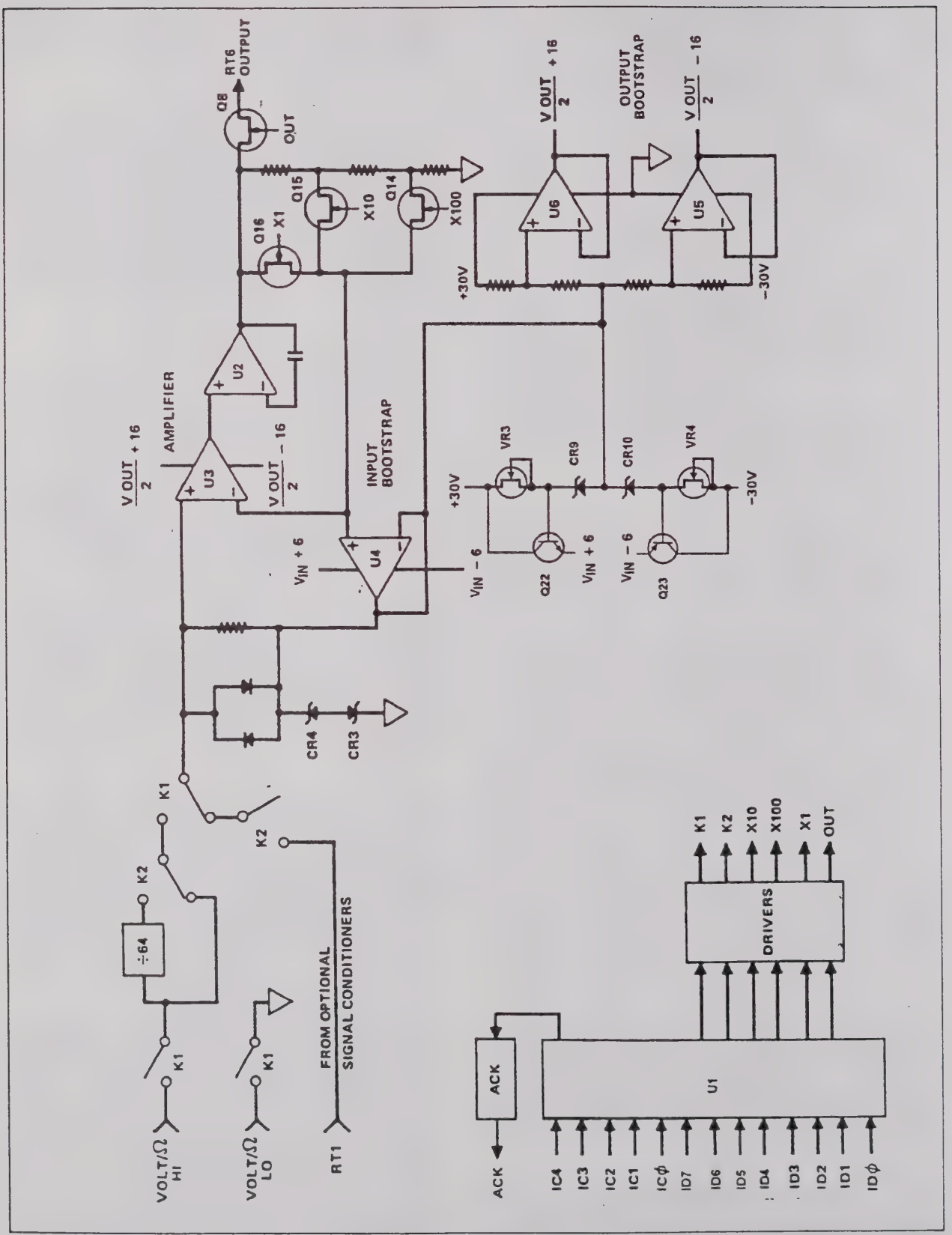


Figure 3-18. DC Signal Conditioner

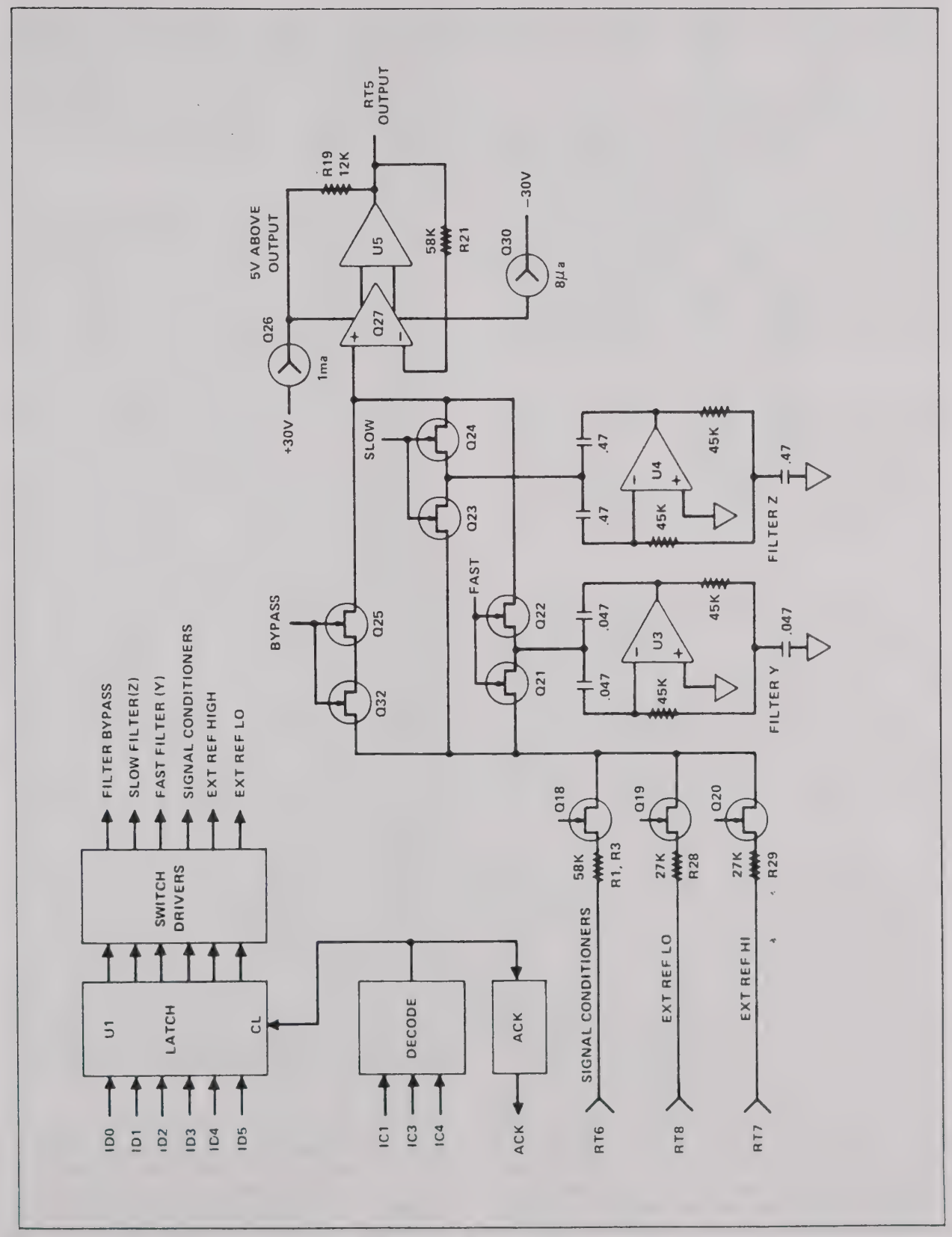


Figure 3-19. Filter/External Reference

addressing the A/D module, the A/D conversion program could be considered a functional part of the A/D Converter.

3-78. ANALOG

3-79. Figure 3-20 is a simplified schematic of the analog portion of the A/D Converter. For clarity, switches are shown as a circle enclosing a letter designator. U1 is a reference and reference amplifier controlling U2, a current source. The -7V reference is set by R9 and R14. U3 serves as a highly regulated collector and zener supply for U1. Operation of the A/D Converter requires both a positive and negative reference (for negative and positive inputs, respectively). Q9 and U4 are a precision unity gain amplifier whose input is controlled by switches A1 and A2. With A1 closed and A2 open, Q9 and U4 are a noninverting amplifier.

3-80. An input signal is applied to the Summing Node of the remainder amplifier (Q27, U7) through switch I. Q27 and U7 are an inverting amplifier with two gain configurations. During the decision period, switch G is closed, applying the output of U7 to polarity detector Q28 and forming a feedback path through CR5 and CR6. Q28 sends a polarity bit to the digital portion of the circuitry. On the basis of this first polarity bit, a reference polarity is selected.

3-81. Switches B, C, D, E, and F are closed, one at a time, to switch a precise amount of current into the Summing Node. When a switch is closed, the opposite switch is opened and vice versa. For example, when D is closed, $\overline{D}$ is opened. After a switch is closed, a polarity bit is returned. If the polarity changed with respect to the original polarity selected for a step, the switch is opened; otherwise it is left closed. The next switch is closed, a polarity bit returned and a decision made, and so on until all five switches have been closed (and possibly opened again). This constitutes a decision period.

3-82. Following the decision period is the subtraction period. Switch G is opened and switches X and SX are closed to form a feedback path for the remainder amplifier through the X channel, A 400K resistor, R35, sets the gain of Q27 and U7 at sixteen. The feedback current completes the summation process and the amplified remainder is stored on the C10 in the X channel.

3-83. For the next decision period switches SX and X are opened and switches RX and G are closed. Since Q27 and U7 form an inverting amplifier, the opposite polarity reference from the original selection is automatically selected. The amplified remainder is applied to the Summing Node through U6 and R34. Five decisions are made, followed by a subtraction period using channel Y for feedback and remainder storage. The first decision-subtraction period applies the input signal to the Summing Node. The four following steps apply an amplified remainder, alternating between channel X and channel Y.

3-84. When a sample is complete, the circuits are autozeroed. U8 zeros the remainder amplifier through channel X. Any offset is stored on C13 at the noninverting input of Q27. The switching reference, Q9 and U4, is zeroed by first closing A1 and opening A2 to decrease settling time. Then A1 and A2 are both opened and the Z1 and Z2 switches are closed, storing any offset error on C5.

3-85. DIGITAL

3-86. For the following discussion, refer to the Digital Fast R^2 A/D schematic in Section 8. Direct address IC2, 3, 4 latches data into U34 and U35 controlling input switch I, remainder channel switches (RX, RY, SX, SY), autozero (Z1), and reset (digital). U31, a ring counter, is clocked to the C1 state enabling the indirect address decoder (U33) and the polarity detector (switch G). A polarity bit is returned and applied to U6.

3-87. Indirect address IC1 and IC2 latches the polarity bit in U6, enables the tristate transmitter, U5, and clocks U31 to the C2 state. The transition of U31 from C1 to C2 clocks the polarity into U11 (the uppermost section) whose output determines whether switch A1 or A2 will be closed (reference polarity). At the same time, U1 (uppermost section) is clocked to set the other section of U11, closing the first reference switch, B, of the A/D Converter. The next indirect address clocks a new polarity bit (a result of closing the first reference switch B) into U6. If the polarity changed, the output of U6 will cause a reset of the previous switch latch, opening the previous switch. At termination of the address the next switch is closed. One direct address and six indirect addresses are required to complete a step. The last indirect address resets the control logic to the C0 state.

3-88. Switch selections are made through switch drivers which rely on Vcc and Vss being a -15V and -20V with respect to analog common. This allows simple transition from TTL levels to FET off voltages. D/A Converter switches are selected on transition of U31 from one state to the next. The transition clocks the first of two D-type flip-flops which sets the second. The output of the second latch resets the first and selects the switch. If the polarity does not change after closing a switch, the output of U6 plus the output of U11 (reference select) will place two highs on the input of one section of AND gate U25. Through OR gate, U16, a one will be applied to the D input of that switch latch. The next transition of U31 will clock the latch, keeping the switch closed. If the polarity had changed, a zero would be applied to the D input, opening the switch.

3-89. After the last step, at completion of a sample, the Controller addresses the A/D Converter for autozero. U31 is clocked to the C7 state causing a digital reset. When U6, storage capacitor disable, is reset, autozero is enabled. RC coupled gates delay the zero switch controls so that switch A1 may be closed and A2 opened in the reference switching circuit. This provides a faster settling

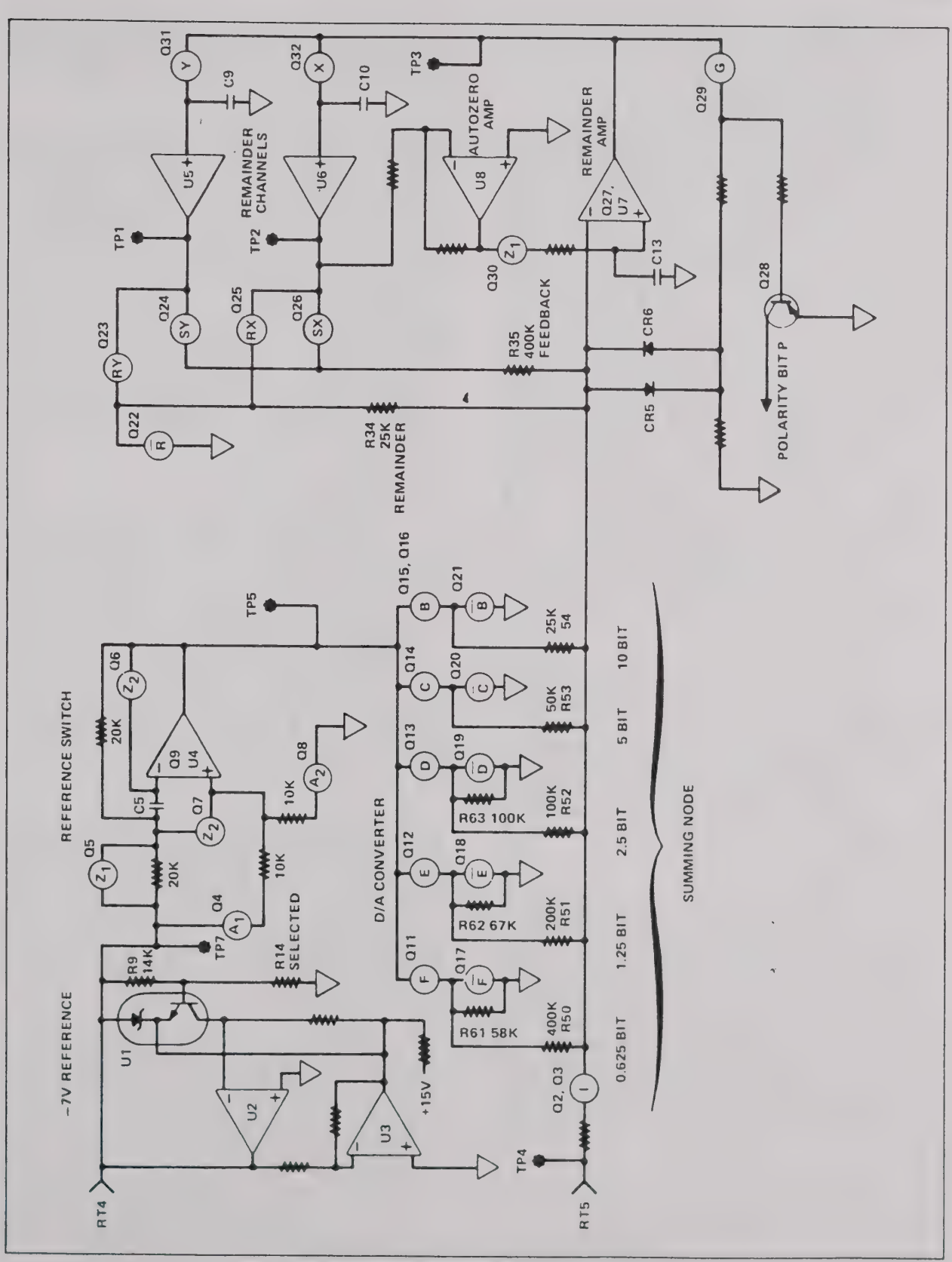


Figure 3-20. Fast R² A/D Converter (Analog)

time for the reference switching amplifier. Both A1 and A2 are opened during the autozero time.

3-90. Thermal True RMS Converter Module

3-91. The following description of the Thermal True RMS Converter module explains a full operating cycle of the high accuracy mode including both a sample mode and hold mode in succession. If the normal mode is selected, the module performs only an abbreviated sample mode and displays the direct output of the Thermal Sensor Circuit, which is updated every 0.5 seconds. If the enhanced mode is selected, one high accuracy measurement is made, and a correction factor computed and stored. The instrument then reverts to a measurement mode similar to that used during normal mode operations, but with the software correction applied to the sensor output. Enhanced is therefore a hybrid mode, using the speed of the normal mode and nearly the same accuracy as found in the high accuracy mode. Due to the hybrid nature of the enhanced mode, the following conditions must be maintained to preserve accuracy: the high accuracy measurement must be made within one hour at a temperature within ±1°C of the working measurement and the deviation of the input from the level of the high accuracy measurement must be less than 1%. If the latter condition is not maintained, the instrument automatically re-initiates a new high accuracy measurement.

3-92. The description of the Thermal True RMS Converter module is divided into four sections. The first explains the mode timing. The second covers the decoding of the logic to control the module operation. The third and fourth sections deal with the two basic modes of operation, the sample mode and the hold mode. Refer to the block diagram of the module in Figure 3-10 and the diagram of the module in the multimeter operation in Figure 3-21 as required during the explanation.

3-93. MODE TIMING

3-94. A high accuracy measurement with the Thermal True RMS Converter module requires a full cycle of operation, i.e. one sample mode (3.5 seconds) and one hold mode (2.5 seconds). The instrument constantly cycles between sample and hold modes during high accuracy measurements; however, if the input is not present at the beginning of the cycle, the accuracy of the measurement cannot be guaranteed. To ensure full settling time and complete accuracy for the first reading, either trigger the instrument from the front panel or wait until the second reading is displayed (a maximum of 12 seconds).

3-95. The measurement takes a total of 6 seconds to complete. Three seconds are required for the thermal sensor to settle, and half a second is required for the dc measurement to be made. Then, while the multimeter processes the sensor output via the normal dc signal path, the stored sensor output is applied to the sensor which requires an additional 2 seconds to settle and another half second for the second dc measurement to be made.

3-96. LOGIC CONTROL

3-97. Controlling instructions enter the module on the IC and ID Bus lines from the controller module. The instructions may originate at the front panel or on the IEEE Bus from a remote source. Address lines IC0, IC1 and IC4 must be high for the module to be addressed. If the proper address is decoded in the Logic Gates/ Latches, an ACK is returned to the bus and the data on the ID Bus is latched into flip-flops. The data is then decoded in the Logic Controls block and used to control gain, switches, relays and attenuators in the circuit. The data required on ID4 through ID7 to select the mode of operation (Sample or Hold), select the filter IN or OUT, select AC or AC+DC coupling, and to activate or deactivate the module is shown in Table 3-2. The data required on ID0 through ID3 to control the Attenuation, Gain, and Range selected is given in Table 3-3.

3-98. SAMPLE MODE

3-99. The unknown rms signal is applied to the Input Circuit where it is coupled to the Input Relays. Either AC (through a capacitor) or AC+DC (bypassing the capacitor) coupling is selected by the Logic Controls. One of the Input Relays is energized by the Logic Controls to route the signal to the Attenuator Circuits for attenuation by either 0.00167, 0.008, 0.08, or 0.8 according to the selected range. The attenuation brings the signal to within a 0.1 to 1-volt span before it is applied to the Ranging Amplifier. When the signal leaves the Attenuator PCB Assembly it passes through a cable with a driven Guard en route to the Ranging Amplifier, which is on the Amplifier PCB Assembly.

3-100. The gain of the Ranging Amplifier is either 2, 6.25, or 20, as determined by the ID Bus inputs to the Logic Controls. The Ranging Amplifier output is applied to the Amplifier Switching circuit and to the Attenuator Circuits on the Attenuator PCB Assembly through a coaxial cable as feedback for compensation at high frequencies. The Amplifier Switching circuit is enabled during the sample mode to allow the input rms signal to be applied to the Thermal Sensor Circuit.

3-101. The Thermal Sensor Circuit consists of a Fluke thermal sensor, a sensor amplifier, and a square root amplifier. Combined they produce a dc output that is equivalent to the rms signal input, plus the error of the sensor. The thermal sensor senses the difference between the dc on the output and the ac on the input, the sensor amplifier provides feedback to bring the output dc to the value equal to the ac input, and the square root amplifier enhances transient response. The output is applied first to the Output Amplifier (X1) and then the Output Switching circuit for routing, under software logic control, to the instrument main bus for action by the DC Signal

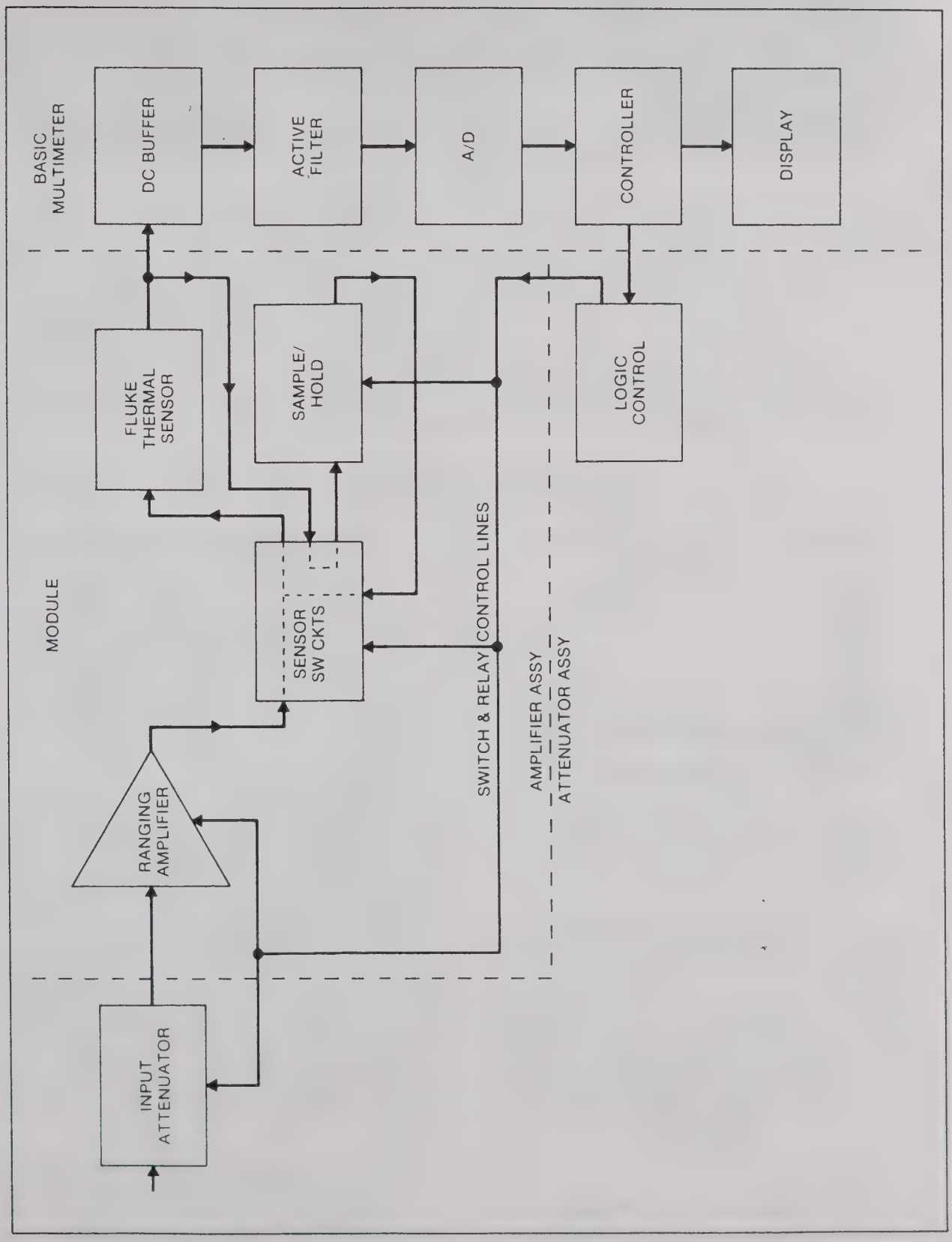


Figure 3-21. Thermal True RMS Conversion

Table 3-2. Module Commands Logic

ID4	ID5	ID6	ID7	SAMPLE/HOLD	FILTER	COUPLING	MODULE
L	L	L	L	HOLD	OUT	AC	ON
L	L	L	H	HOLD	OUT	AC	OFF
L	L	H	L	HOLD	OUT	AC + DC	ON
L	L	H	H	HOLD	OUT	AC + DC	OFF
L	H	L	L	HOLD	IN	AC	ON
L	H	L	H	HOLD	IN	AC	OFF
L	H	H	L	HOLD	IN	AC + DC	ON
L	H	H	H	HOLD	IN	AC + DC	OFF
H	L	L	L	SAMPLE	OUT	AC	ON
H	L	L	H	SAMPLE	OUT	AC	OFF
H	L	H	L	SAMPLE	OUT	AC + DC	ON
H	L	H	H	SAMPLE	OUT	AC + DC	OFF
H	H	L	L	SAMPLE	IN	AC	ON
H	H	L	H	SAMPLE	IN	AC	OFF
H	H	H	L	SAMPLE	IN	AC + DC	ON
H	H	H	H	SAMPLE	IN	AC + DC	OFF

Table 3-3. Decoded ID Bus Logic

ID0	ID1	ID2	ID3	ATTENUATOR (AT)	GAIN (AV)	RANGE
L	L	L	H	0.8	X20	100 mV
L	L	H	L	0.8	X6.25	300 mV
L	L	H	H	0.8	X2	1V
L	H	H	H	0.00167	X2	500V
H	L	H	L	0.008	X6.25	30V
H	L	H	H	0.008	X2	100V
H	H	H	L	0.08	X6.25	3V
H	H	H	H	0.08	X2	10V

NOTE: Logic High = -15V DC, Logic Low = -20V DC

Conditioner. The Protection Circuit monitors the temperature of the Thermal Sensor Circuit. If the internal temperature of the Fluke thermal sensor reaches approximately 100°C, the Protection Circuit limits the output of the Ranging Amplifier.

3-102. The signal from the Output Amplifier is also routed to the S/H Input Switching circuit for application to the sample/hold circuit. When the sample mode is in progress the S/H Input Switching is enabled while S/H Sense Switching and S/H Output Switching are disabled. The sample/hold circuit multiplies the signal from the Output Amplifier by five. The resultant signal is stored on a capacitor (C34). The signal is multiplied to reduce the effect of leakage current in the storage capacitor. The sample mode is complete when the signal is stored in the capacitor.

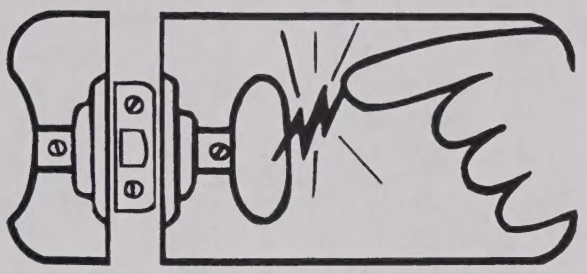
3-103. HOLD MODE

3-104. When the module goes into the hold mode the Amplifier Switching and S/H Input Switching circuits are disabled and the S/H Sense Switching and S/H Output Switching circuits are enabled. The unknown rms signal is still applied to the input circuits but it is blocked at the Amplifier Switching circuit from going into the Thermal Sensor Circuit. Instead, the value stored in the sample/hold circuit is withdrawn from the capacitor and divided by five to return the stored value to the original magnitude. The result is then applied to the Thermal Sensor Circuit through the S/H Output Switching circuit. The value applied is sensed at the Thermal Sensor input and returned through the S/H Sense Switching circuit to the sample/hold circuit. The signal from the sample/hold circuit is processed by the Thermal Sensor circuit in exactly the same manner as the unknown signal from Input circuit. The output is directed through the Output Amplifier and Output Switching circuits to the DC Signal Conditioner.

3-105. The hold mode result and the sample mode result are processed in the Controller Module to obtain the true rms value of the input signal. The result of the computation is then sent to the Front Panel for display until another cycle is performed.

static awareness

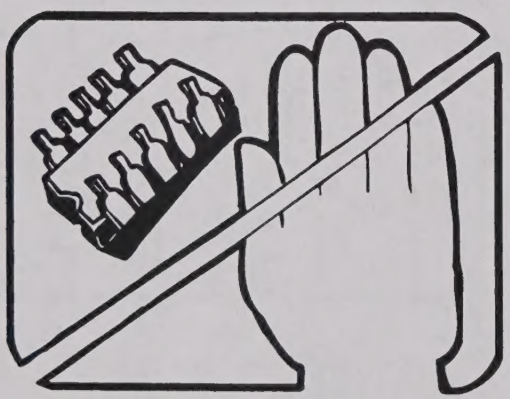
A Message From
Fluke Corporation



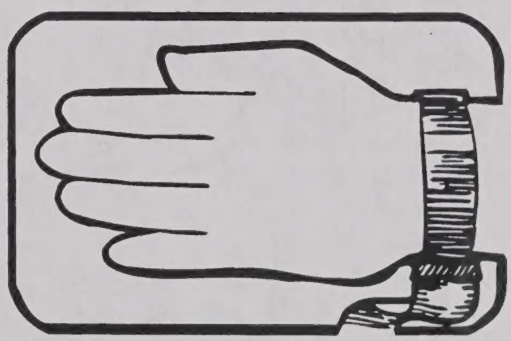
Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

1. Knowing that there is a problem.
2. Leaning the guidelines for handling them.
3. Using the procedures, packaging, and bench techniques that are recommended.

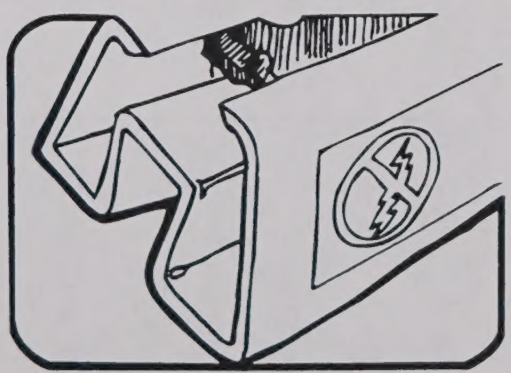
The following practices should be followed to minimize damage to S.S. (static sensitive) devices.



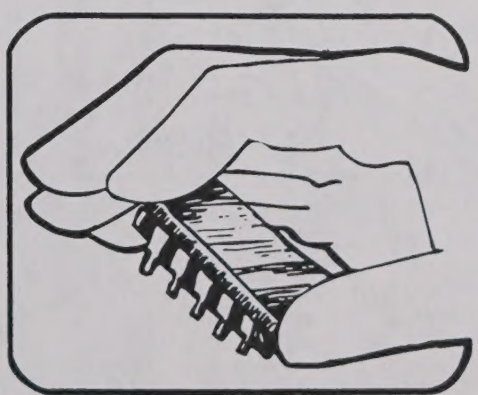
1. MINIMIZE HANDLING



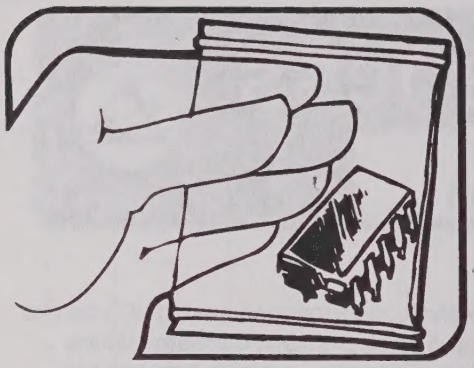
3. DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES. USE A HIGH RESISTANCE GROUNDING WRIST STRAP.



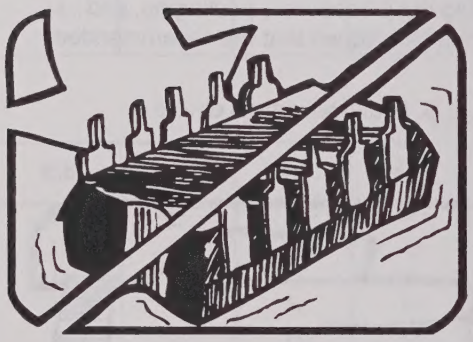
2. KEEP PARTS IN ORIGINAL CONTAINERS UNTIL READY FOR USE.



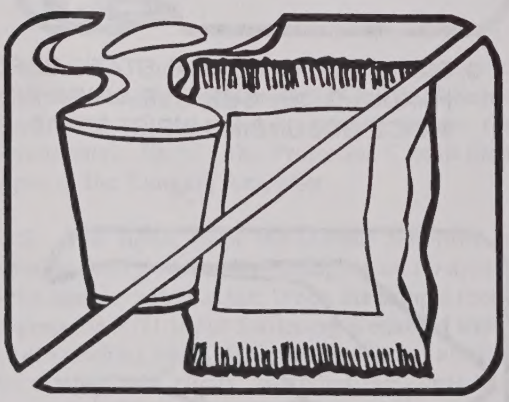
4. HANDLE S.S. DEVICES BY THE BODY.



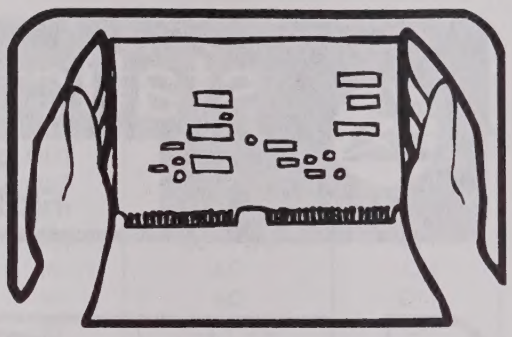
5. USE STATIC SHIELDING CONTAINERS FOR HANDLING AND TRANSPORT.



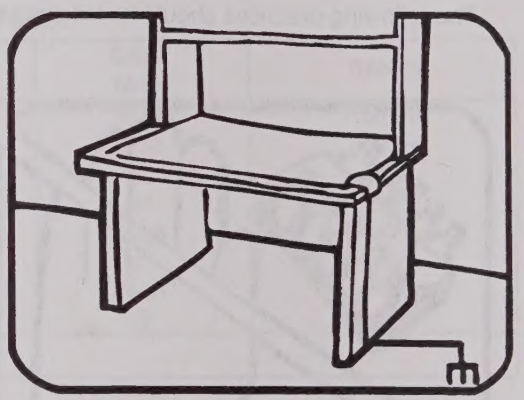
6. DO NOT SLIDE S.S. DEVICES OVER ANY SURFACE.



7. AVOID PLASTIC, VINYL AND STYROFOAM® IN WORK AREA.



8. WHEN REMOVING PLUG-IN ASSEMBLIES HANDLE ONLY BY NON-CONDUCTIVE EDGES AND NEVER TOUCH OPEN EDGE CONNECTOR EXCEPT AT STATIC-FREE WORK STATION. PLACING SHORTING STRIPS ON EDGE CONNECTOR HELPS PROTECT INSTALLED S.S. DEVICES.



9. HANDLE S.S. DEVICES ONLY AT A STATIC-FREE WORK STATION.

10. ONLY ANTI-STATIC TYPE SOLDER-SUCKERS SHOULD BE USED.

11. ONLY GROUNDED-TIP SOLDERING IRONS SHOULD BE USED.

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